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**CHEMISTRY**

**UNITS 3 & 4**

**2022**

**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 | 83 | 35 |
| Section Three  Extended answer | 5 | 5 | 70 | 94 | 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% (83 marks)**

**Question 26 (11 marks)**

(a) Complete the flow chart, by writing the name of each organic substance in the boxes labelled X, Y and Z. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| X is butan-1-ol | 1 |
| Y is butanoic acid | 1 |
| Z is butanone | 1 |
| **Total** | **3** |

(b) Write a balanced ionic equation for the reaction that produced the colourless, odourless gas. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Correct reactants and products | 1 |
| Balanced | 1 |
| **Total** | **2** |
| Examples of a two mark response:  2 CH3CH2CH2COOH(aq) + Na2CO3(s) →  2 CH3CH2CH2COO-(aq) + 2 Na+(aq) + CO2(g) + H2O(l)  2 C3H7COOH(aq) + Na2CO3­­­(s) → 2 C3H7COO-(aq)+ 2 Na+(aq) + CO2(g) + H2O(l) | |
| Note:  one mark may be allocated for the correctly balanced molecular equation | |

(c) Rank the 3 original organic substances in order of boiling point, and explain your answer by referring to the intermolecular forces present in each substance. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Butanoic acid > butan-1-ol > butanone | 1 |
| The greater the sum of intermolecular forces, the higher the boiling point. | 1 |
| Substances have similar M, therefore similar strength dispersion forces. | 1 |
| Butanone has only dipole-dipole forces (in addition to dispersion) and therefore has the lowest boiling point. | 1 |
| Butan-1-ol and butanoic acid have hydrogen bonding (in addition to dipole-dipole and dispersion forces) which elevate their boiling point. | 1 |
| The hydrogen bonding in butanoic acid is the strongest because the -COOH group is more polar than the -OH group.  **or**  Butanoic acid molecules form dimers, with stronger hydrogen bonds (than those in butan-1-ol).  **or**  The boiling point of butanoic acid is the highest because it has more potential hydrogen bonding sites (than butan-1-ol). | 1 |
| **Total** | **6** |

**Question 27 (8 marks)**

(a) Describe how the equations above demonstrate an understanding of the following terms. Your answer may refer to one or both equations, as required. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Bronsted-Lowry theory: |  |
| * one species (the aspartic acid) is acting as a proton (H+) donor * whilst the other species (water) is acting as a proton (H+) acceptor | 2 |
| Diprotic: |  |
| * aspartic acid contains two ionisable / acidic hydrogens per molecule * illustrated by use of two successive ionisation equations | 2 |
| Weak acid: |  |
| * partial ionisation of aspartic acid occurs * illustrated by use of reversible / double arrows in both equations | 2 |
| **Total** | **6** |

(b) Which of the ionisation steps would have a higher Ka value? (circle your choice) (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Step 1 (circled) | 1 |
| **Total** | **1** |

(c) Draw a structural diagram for the conjugate acid of ‘aspartic acid’. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Correct structural diagram (accept full or semi structural) | 1 |
| **Total** | **1** |
| Example of a correct structure:  CH2 – COOH  l  H3N – CH – COOH  ⊕ | |

**Question 28 (8 marks)**

(a) State an observation that would allow silver and cobalt to be identified. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Silver: |  |
| no visible change | 1 |
| Cobalt: |  |
| pink solution formed | 1 |
| **Total** | **2** |

(b) Write a balanced ionic equation, illustrating the reaction that took place between HCl(aq) and these two metals, **using the symbol X** to represent both Sn and Zn. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Correct reactants and products | 1 |
| Balanced | 1 |
| **Total** | **2** |
| Example of a two mark response:  X(s) + 2 H+(aq) → X2+(aq) + H2(g) | |

(c) Describe how this would allow these solutions to be distinguished. Include any relevant chemical equations and observations in your answer. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Zinc solution: |  |
| No reaction / no visible change when cobalt added to zinc solution | 1 |
| Tin solution: |  |
| A (metal displacement) reaction occurs when cobalt added to tin solution | 1 |
| Any two of;   * silver metal dissolves * pink solution forms * new silver-grey solid forms | 1 |
| Equation: |  |
| Example of correct equation:  Co(s) + Sn2+(aq) → Sn(s) + Co2+(aq) | 1 |
| **Total** | **4** |

**Question 29 (10 marks)**

(a) Using your knowledge of IUPAC nomenclature, match each of these 3 ingredients to their corresponding molecular structure. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Molecule 1: propanediol | 1 |
| Molecule 2: citric acid | 1 |
| Molecule 3: glyceryl oleate | 1 |
| **Total** | **3** |

(b) Describe a ‘polypeptide’. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two of the following: |  |
| * condensation polymer * a naturally occurring polyamide * a long chain of amino acids * joined together by peptide / amide bonds / links | 2 |
| **Total** | **2** |

(c) State the key difference between the secondary and tertiary structure of a protein. Give at least one example of each type of structure. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Secondary structure: |  |
| Interactions / hydrogen bonds that form between C=O and N-H groups of amino acids / within a protein chain.  **or**  Regular structures that form due to interactions / hydrogen bonding that occur between amino acids / within a protein chain. | 1 |
| and either of the following examples: |  |
| * a-helix * b-pleated sheet | 1 |
| Tertiary structure: |  |
| Various interactions which occur between the amino acid side chains. | 1 |
| and any one of the following examples: |  |
| * dispersion forces * dipole-dipole forces * hydrogen bonds * ionic bonds * disulfide bridge | 1 |
| **Total** | **4** |

(d) What does ‘PET’ stand for? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| polyethylene terephthalate | 1 |
| **Total** | **1** |

**Question 30 (5 marks)**

(a) Write the equilibrium constant (K) expression for this system. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Products over reactants | 1 |
| Correct indices | 1 |
| **Total** | **2** |
| Example of a two mark response:  K = [Mg2+] [HCO3- ]2  [CO2] | |

(b) Consider the effect of imposing the following changes on this system. Complete the table below by stating in which direction, if any, an equilibrium shift would occur. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| A small amount of MgCO3(s) is added. | no change | 1 |
| A few drops of 2 mol L-1 MgCl2(aq) is added. | left | 1 |
| The volume of the system is decreased. | right | 1 |
| **Total** | | **3** |

**Question 31 (11 marks)**

(a) What is an enzyme? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A biological catalyst  **or**  A protein which acts as a catalyst | 1 |
| **Total** | **1** |

(b) List four (4) additional advantages, relating to the principles of green chemistry, of the fermentation method of producing ethanol. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any four of the following: |  |
| * use of a lower pressure * use of a lower temperature * no unwanted side reactions (due to use of catalyst) * no use of corrosive acid catalyst * use of renewable feedstock * less hazardous * (closer to) carbon neutral fuel | 4 |
| **Total** | **4** |

(c) Complete the reaction sequence below, by filling in the boxes. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Step 1: H2O | 1 |
| Step 2: 4 Cr3+ | 1 |
| Step 3: CH3CH2OH | 1 |
| **Total** | **3** |

(d) Name the type of reaction occurring in each step of the sequence. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Step 1: addition / hydration | 1 |
| Step 2: oxidation / redox | 1 |
| Step 3: esterification / condensation | 1 |
| **Total** | **3** |

**Question 32 (11 marks)**

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

* anode and cathode
* direction of electron flow
* direction of anion flow through the salt bridge.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Cathode and anode labels | 1 |
| Direction of electron flow label | 1 |
| Direction of anion flow label | 1 |
| **Total** | **3** |
| Example of a three mark response:  electrons  anions  V  anode cathode |  |

(b) Calculate the EMF of the cell under standard conditions. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| EMF = + 0.80 + 0.24 = + 1.04 V | 1 |
| **Total** | **1** |

(c) Calculate the final mass of the silver electrode. (7 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Ni) = 10 / 58.69  = 0.170387 mol | 1 |
| n(Ag+) = 1 x 0.5  = 0.5 mol | 1 |
| Appropriate working to demonstrate limiting reagent |  |
| actual ratio Ag+ / Ni = 2  stoichiometric ratio Ag+ / Ni = 2.9345  **or**  n(Ni required) = 0.25 mol  n(Ag+ required) = 0.34077 mol | 1 |
| Ni is limiting reagent (with appropriate justification) | 1 |
| n(Ag formed) = 2 x n(Ni)  = 0.34077 mol | 1 |
| m(Ag formed) = 0.34077 x 107.9  = 36.7695 g | 1 |
| m(Ag electrode) = 10 + 36.7695  = 46.8 g | 1 |
| **Total** | **7** |

**Question 33 (11 marks)**

(a) Explain, in terms of reaction rates, how this buffer would respond to the addition of H3O+(aq) as caused by rainfall. Include a relevant chemical equation in your answer. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| An increase in H3O+ would neutralise / remove OH- ions from the system. | 1 |
| Both forward and reverse reaction rates would decrease, | 1 |
| however the forward reaction rate decreases less than the reverse rate. | 1 |
| This results in the position of equilibrium shifting right, | 1 |
| resulting in production of more OH- ions and therefore the pH is maintained. | 1 |
| Equation showing H3O+ reaction with conjugate base species | 1 |
| Example of correct equation:  H3O+(aq) + SiO44-(aq) → H2O(l) + HSiO43-(aq) |  |
| **Total** | **6** |

(b) State the two (2) factors that would affect the buffering capacity of this system. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ratio of the concentrations of acid (HSiO43-) and base (SiO44-) | 1 |
| Actual / absolute concentrations of acid (HSiO43-) and base (SiO44-) | 1 |
| **Total** | **2** |

(c) Use Le Chatelier’s principle, to justify how an increase in the concentration of atmospheric CO2(g) can lower the ocean pH. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| An increase in CO2 concentration favours the forward reaction / shifts the position of equilibrium to the right in equations 1, 2 and 3. | 1 |
| This counteracts the imposed change by decreasing the CO2, but results in increased [H3O+ ]. | 1 |
| As [H3O+ ] increases, pH is lowered (since pH = -log[H3O+]). | 1 |
| **Total** | **3** |

**Question 34 (8 marks)**

(a) What type of condensation polymer is shown? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A polyester | 1 |
| **Total** | **1** |

(b) Draw structural diagrams of the monomers used to produce this polymer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Diacid: | 1 |
| Diol: | 1 |
| **Total** | **2** |

(c) Define ‘crosslinking’. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The formation of (usually) covalent bonds between polymer chains. | 1 |
| **Total** | **1** |

(d) Choose one (1) of these altered properties, and describe how crosslinking can result in this change to the polymer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Higher melting point: |  |
| The crosslinked polymer chains have a much greater molecular mass (M) / The crosslinks result in formation of a polymer network. | 1 |
| This increases the strength of intermolecular forces (resulting in an increased melting point) / This results in a greater amount of heat required to melt the polymer (which may in fact char before melting). | 1 |
| **Total** | **2** |

**or**

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Higher physical strength: |  |
| The crosslinked polymer chains have a decreased ability to slide past each other / The crosslinks result in a polymer network. | 1 |
| This enables the polymer to withstand a greater application of force (resulting in an increased physical strength) / This results in a more rigid and strong polymer structure. | 1 |
| **Total** | **2** |

(e) Draw a structural diagram and give the name for the **new** monomer that has been used to form this crosslinking polymer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Structure: | 1 |
| Name: glycerol / propane-1,2,3-triol | 1 |
| **Total** | **2** |

**Section Three: Extended answer 40% (94 marks)**

**Question 35 (24 marks)**

(a) Calculate the minimum pressure that would need to be exerted by the O2(g) in the reaction chamber, to ensure sufficient O2(g) was present for all the chromite to react. State your answer to the appropriate number of significant figures. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(FeCr2O4) = 3.21 x 106 / 223.85  = 14 339.96 mol | 1 |
| n(O2) = 7/4 x n(FeCr2O4)  = 25 094.93 mol | 1 |
| P(O2) = (25 094.93 x 8.314 x 1373.15) / (1500 x 103)  = 190.995 kPa | 1 |
| = 191 kPa (correct to 3 significant figures) | 1 |
| Correct conversions, t → g, kL → L, °C → K | 1 |
| **Total** | **5** |

If the combined yield of Step 1 and Step 2 is 68.9%;

(b) Calculate the mass of Na2Cr2O7(s) produced. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Correct theoretical stoichiometric ratio of n(Na2Cr2O7) = n(FeCr2O4) | 1 |
| n(Na2Cr2O7) = n(FeCr2O4) x 68.9/100 | 1 |
| = 14 339.96 x 68.9/100  = 9 880.23 mol | 1 |
| m(Na2Cr2O7) = 9 880.23 x 261.98  = 2 588 423 g (2.59 x 106 g or 2.59 t) | 1 |
| **Total** | **4** |

(c) Calculate the percentage yield of Step 3. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Cr2O3 theor.) = n(Na2Cr2O7)  = 9 880.23 mol | 1 |
| m(Cr2O3 theor.) = 9 880.23 x 152  = 1 501 795 g (1.502 x 106 g or 1.502 t) | 1 |
| % yield = 1.28 / 1.502 x 100  = 85.2 % | 1 |
| **Total** | **3** |
| Alternate method:  n(Cr2O3 actual) = 1.28 x 106 / 152  = 8 421.053 mol  % yield = 8 421.053 / 9 880.23 x 100  = 85.2 % |  |

(d) Calculate the concentration of Cr3+(aq) ions, in **grams per litre**, in the final solution.

(4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Cr2O3 actual) = 1.28 x 106 / 152  = 8 421.053 mol | 1 |
| n(Cr3+) = 2 x n(Cr2O3)  = 16 842.105 mol | 1 |
| c(Cr3+) = 16 842.105 / 3500  = 4.812 mol L-1 | 1 |
| c(Cr3+) = 4.812 x 52  = 250.2 g L-1 | 1 |
| **Total** | **4** |
| Alternate method for final two steps:  m(Cr3+) = 16 842.105 x 52  = 875 789 g  c(Cr3+) = 875 789 / 3500  = 250.2 g L-1 |  |

(e) What is an electrolytic cell? (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| One of the following: |  |
| * cell that uses an external power source that * cell which converts electrical energy to chemical energy and | 1 |
| with either of: |  |
| * drives a non-spontaneous redox reaction * causes a redox reaction with a negative EMF to occur | 1 |
| **Total** | **2** |

(f) Describe how the electrolyte solution for this cell could be prepared to standard conditions, using the Cr3+(aq) solution. Your answer should include appropriate calculations. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Cr3+ required) = 1 x 850  = 850 mol | 1 |
| V(Cr3+ required) = 850 / 4.812  = 176.64 L | 1 |
| Add 177 L of Cr3+ solution to tank, fill to 850 L with water | 1 |
| Cool solution to final temperature of 25 °C | 1 |
| **Total** | **4** |
| Alternate calculation method for two marks:  V1 = c2V2 / c1  = 1 x 850 / 4.812  = 176.64 L  Note: award follow through marks for correct working based on incorrect initial Cr3+(aq) concentration from part (d). |  |

(g) Add to this diagram by labelling; (2 marks)

* where you would connect the inert graphite electrode,
* where you would connect the car door handle, and
* the direction of electron flow.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Door handle on left (-)  Graphite on right (+) | 1 |
| Direction of electron flow label | 1 |
| **Total** | **2** |
| Example of a three mark response:  – +  electrons  door handle  graphite electrode |  |

**Question 36 (16 marks)**

(a) Select an appropriate indicator from the table below for use in this titration. Justify your indicator choice, including a relevant chemical equation in your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Thymol blue | 1 |
| Basic solution at equivalence due to hydrolysis of C6H7O6- (ascorbate ions) | 1 |
| Balanced equation | 1 |
| **Total** | **3** |
| Example of correct equation:  C6H7O6-(aq) + H2O(l) ⇌ C6H8O6(aq) + OH-(aq) | |

(b) Calculate the concentration of Vitamin C in the dried gumbi-gumbi leaves, expressing your final answer as ‘**mg of Vitamin C per 100 g gumbi-gumbi leaves**’.

(You may assume the ascorbic acid was the only acidic substance present in the leaves.) (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(NaOH) = 0.01118 x 0.01828  = 0.00020437 mol | 1 |
| n(C6H8O6) = n(NaOH)  = 0.00020437 mol | 1 |
| m(C6H8O6) = 0.00020437 x 176.124  = 0.0359945 g | 1 |
| = 35.9945 mg (in 25 mL / in 30 g) | 1 |
| m(C6H8O6 in 100 g) = 35.9945 x 100/30  = 119.98 mg  = 120 mg | 1 |
| **Total** | **5** |

(c) Draw structural formulas for both ascorbic and palmitic acid. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ascorbic acid: | 1 |
| Palmitic acid:    **or**  CH3(CH2)14COOH | 1 |
| **Total** | **2** |

(d) Explain, in terms of intermolecular forces, why ascorbic acid is a water-soluble vitamin but ascorbyl palmitate is a fat-soluble vitamin. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Water and ascorbic acid both exhibit hydrogen bonding as their predominant intermolecular interaction. | 1 |
| Thus new hydrogen bonds (as well as dipole-dipole and dispersion forces) are able to form between water and ascorbic acid. | 1 |
| These new hydrogen bonds (and dipole-dipole and dispersion forces) are sufficient in strength to disrupt / release sufficient energy to overcome the existing intermolecular forces withinboth water and ascorbic acid (and therefore they are soluble). | 1 |
| The large non-polar region (and greater size) of ascorbyl palmitate, means it interacts predominantly through dispersion forces. | 1 |
| Fats are also non-polar / interact largely through dispersion forces, and | 1 |
| therefore the new dispersion forces formed between fat and ascorbyl palmitate are sufficient in strength to disrupt / release sufficient energy to overcome the existing intermolecular forces within both fat and ascorbyl palmitate (and therefore they are soluble). | 1 |
| **Total** | **6** |

**Question 37 (17 marks)**

(a) Describe what is happening to both the forward and reverse reaction rates from Time 0 to Time E1. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Decrease in forward reaction rate. | 1 |
| Increase in reverse reaction rate. | 1 |
| At time E1 the forward and reverse reaction rates become equal. | 1 |
| **Total** | **3** |

(b) Complete the table below, by stating how the pressure and temperature of the system are different at Time E1, compared to Time 0. Justify each of your choices. (4 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Pressure | |  |
| Conditions | decreased (circled) | 1 |
| Justification | 3 : 2 molar ratio of gaseous reactants : products | 1 |
| Temperature | |  |
| Conditions | increased (circled) | 1 |
| Justification | forward reaction is exothermic | 1 |
| **Total** | | **4** |

(c) Explain, in terms of the collision theory, why the actual temperature used in the Contact Process is not lowered to 300 °C. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A lower temperature would: |  |
| Decrease the frequency of collisions, and | 1 |
| decrease the average kinetic energy of the reacting particles. | 1 |
| This would result in a lower proportion of particles able to react / overcome the activation energy barrier, | 1 |
| therefore the reaction rate would decrease to non-viable levels. | 1 |
| **Total** | **4** |

(d) State the change that was imposed, and justify why the system would temporarily be classified as an ‘open system’. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Removal of SO3(g). | 1 |
| Matter being removed from the system (therefore classified as open). | 1 |
| **Total** | **2** |

(e) State when (i.e. at Time E1, E2 or E3) the value of Kc would have been highest and when it would have been lowest. Justify your answers. (4 marks)

(Note: calculations of Kc values are not required.)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equal highest at E2 and E3. | 1 |
| Lowest at E1. | 1 |
| After E1, the temperature is decreased, which favours the forward reaction / increases the yield, and increases the value of K. | 1 |
| After E2, there are no imposed changes that would affect the value of K. | 1 |
| **Total** | **4** |

**Question 38 (17 marks)**

(a) State which two (2) pieces of glassware the chemist should use to perform the NaOH(aq) dilution. Justify your answer using appropriate calculations. (7 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Approximate concentration of base |  |
| n(NaOH) = 160 / 39.998  = 4.0002 mol | 1 |
| c(NaOH) = 4.0002 / 0.5  = 8.0004 mol L-1 | 1 |
| Moles of acid present in 20 mL |  |
| n(H2C2O4) = 0.2074 x 0.020  = 0.004148 mol | 1 |
| Approximate requirements for an equivalent titre volume (~20 mL) |  |
| n(NaOH required) = 2 x n(H2C2O4)  = 0.008296 mol | 1 |
| c(NaOH required) = 0.008296 / 0.020  = 0.4148 mol L-1 | 1 |
| Dilution factor required = 8.0004 / 0.4148 ≈ 20 fold | 1 |
| Use **25 mL pipette** and **500 mL volumetric flask** | 1 |
| **Total** | **7** |
| Note:  Award equivalent marks for alternate working, including partly ‘worded’ justifications such as “conical flask aliquot and average titre should be approximately the same volumes, therefore the concentration of base would need to be approximately double the concentration of acid” etc | |

(b) Calculate the resulting pH of the sodium hydroxide solution. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(NaOH) = 7.86 x 0.380  = 2.9868 mol | 1 |
| c(NaOH final) = 2.9868 / 0.490  = 6.09551 mol L-1 | 1 |
| [H+] = (1.0 x 10-14) / 6.09551  = 1.64055 x 10-15 mol L-1 | 1 |
| pH = - log (1.64055 x 10-15)  = 14.785 (14.8) | 1 |
| **Total** | **4** |

(c) Draw a structural diagram of the triglyceride found in jojoba oil. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Glycerol backbone (accept full or semi structural) | 1 |
| Three identical fatty acids (accept full or semi structural) | 1 |
| **Total** | **2** |
| Example of a two mark response:  CH3 – (CH2)7 – CH = CH – (CH2)9 – COOCH2  l  CH3 – (CH2)7 – CH = CH – (CH2)9 – COOCH  l  CH3 – (CH2)7 – CH = CH – (CH2)9 – COOCH2 | |
| Note:  one mark may be allocated if there is only one minor error  e.g. one H atom missing, one subscript error in fatty acid formula, etc | |

(d) Draw the chemical structure of the scum that would form if this soap was used in hard water. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Both ions in formula correct (accept Ca2+/ Mg2+/ Fe2+) | 1 |
| Correct subscript (i.e. 2) for soap anion | 1 |
| **Total** | **2** |
| Example of a two mark response:  Ca(CH3(CH2)7CH=CH(CH2)9COO)2 | |
| Note:  one mark may be allocated if there is only one minor error  e.g. one subscript error in fatty acid formula, etc | |

(e) Draw a structural diagram for an anionic detergent with the same number of carbon atoms as the soap. Assume the detergent is an ‘alkylbenzene sulfonate’. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Benzene ring and sulfonate group (accept full or semi structural) | 1 |
| Alkyl group with 14 carbons (accept full or semi structural) | 1 |
| **Total** | **2** |
| Example of a two mark response: | |
| Note:  one mark may be allocated if there is only one minor error  e.g. charge missing from sulfonate group, etc | |

**Question 39 (20 marks)**

(a) Demonstrate that this is a redox reaction, using oxidation numbers to support your answer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Zinc is oxidised, oxidation number changes from (0) to (+2) | 1 |
| Carbon is reduced, oxidation number changes from (-2/3) to (-1) | 1 |
| **Total** | **2** |

(b) Predict the substance formed, in addition to toluene. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| HCl / hydrochloric acid / hydrogen chloride | 1 |
| **Total** | **1** |

(c) Write the oxidation and reduction half-equations and overall redox reaction for this process, assuming acidic conditions. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Correctly identifying which half-equation is oxidation and which is reduction | 1 |
| Oxidation half-equation: |  |
| Correct reactants and products | 1 |
| Correct balancing | 1 |
| Example of a two mark response:  CH3  COOH  + 2H2O(l) → + 6H+(aq) + 6e-  **or**  C7H8(l) + 2H2O(l) → C7H6O2(aq) + 6H+(aq) + 6e- |  |
| Reduction half-equation: |  |
| Correct reactants and products | 1 |
| Correct balancing | 1 |
| Example of a two mark response:  MnO4-(aq) + 4H+(aq) + 3e- → MnO2(s) + 2H2O(l) |  |
| Overall equation: |  |
| Correctly written and balanced equation | 1 |
| Example of correct equation:  CH3  COOH  + 2MnO4-(aq) + 2H+(aq) → + 2MnO2(s) + 2H2O(l)  **or**  C7H8(l) + 2MnO4-(aq) + 2H+(aq) → C7H6O2(aq) + 2MnO2(s) + 2H2O(l) |  |
| **Total** | **6** |

(d) Determine the empirical formula of this compound and thereby identify it. (9 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Calculating moles and mass of C | 2 |
| Calculating moles and mass of H | 2 |
| Calculating moles and mass of O | 2 |
| Determining simplest ratio by dividing all by smallest moles | 1 |
| Writing empirical formula C6H6O | 1 |
| Stating compound is ‘phenol’ | 1 |
| **Total** | **9** |
| Example of a nine mark response:   |  |  |  |  | | --- | --- | --- | --- | |  | **C** | **H** | **O** | | mass (g) | (12.01 / 44.01) x 1.905  = 0.5199 | 0.04328 x 1.008  = 0.04363 | 0.6789 – (0.51986 + 0.043629)  = 0.1154 | | moles (mol) | 0.5199 / 12.01  = 0.04329 | 2x [(168 x 0.5228) /(8.314 x 488.15)]  = 0.04328 | 0.1154 / 16.00  = 0.007213 | | ratio | 0.04329 / 0.007213 = 6.001 | 0.04328 / 0.007213 = 6.000 | 0.007213 / 0.007213 = 1.000 | | 6 | 6 | 1 |   Empirical formula is C6H6O. The identity of the compound is phenol. |  |
| Note:  If mass/moles of oxygen not determined and benzene (C6H6) is given as answer, award a maximum of 6 marks. |  |

(e) Draw the chemical structure of hippuric acid. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Structure of benzoic ‘half’ without -OH group (accept full or semi structural) | 1 |
| Structure of glycine ‘half’ without -H group (accept full or semi structural) | 1 |
| **Total** | **2** |
| Example of a two mark response: | |
| Note:  one mark may be allocated if there is only one minor error | |