YEAR 12 CHEMISTRY

TASK 5 – Volumetric Analysis and REDOX Test

Name:

Teacher:

**INSTRUCTIONS**

* You will be given 45 minutes to complete the test.
* Multiple choice answers should be given on the answer sheet provided.
* Short response questions should be written in the spaces provided.
* Any calculations must show FULL WORKING and be stated to an appropriate number significant figures or marks will be deducted.
* Use BLACK or BLUE pen only.
* Scientific calculators are permitted for this test.
* A Chemistry Data Sheet will be provided with this test.

Test Score:

50

Percentage:

PART ONE: MULTIPLE CHOICE (10 marks)

*Answer the questions by marking the corresponding letter of your selected answer on the answer sheet provided. Each question in this section is worth 1 mark.*

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***Questions 1, 2 and 3 refer to the information below.***

Consider the overall reaction of the rechargeable lead–acid cell.

PbO2(s) + Pb(s) + 4 H+(aq) + 2 SO42–(aq) → 2 PbSO4(s) + 2 H2O(ℓ)

**Question 1**

Which one of the following occurs during discharge of the cell?

a) Lead atoms are both oxidised and reduced.

b) Lead is reduced and hydrogen oxidised.

c) Lead is oxidised and hydrogen reduced.

d) Lead is oxidised and sulfur reduced.

**Question 2**

Which one of the following is re-formed at the anode during recharging?

a) PbSO4

b) PbO2

c) Pb

d) Pb2+

**Question 3**

Used lead acid batteries must be disposed of carefully as they contain hazardous waste. Which of the following statements correctly states why the waste is hazardous?

(i) Lead compounds only are toxic.

(ii) Lead metal and lead compounds are toxic.

(iii) The sulfuric acid electrolyte is corrosive.

(iv) Lead metal only is toxic.

a) i only

b) ii and iii only

c) iv only

d) iii and iv only

***Questions 4 and 5 refer to the diagram below.***



**Question 4**

Which one of the following occurs as this cell operates?

a) the zinc electrode is reduced and increases in mass.

b) the zinc electrode is reduced and decreases in mass.

c) the zinc electrode is oxidised and increases in mass.

d) the zinc electrode is oxidised and decreases in mass.

**Question 5**

Which one of the following shows the overall equation and voltage generated by this cell under standard conditions?

|  |  |  |
| --- | --- | --- |
|  | **Equation** | **Voltage** |
| a) | Zn2+(aq) + Ni(s) → Zn(s) + Ni2+(aq) | 0.52 V |
| b) | Ni2+(aq) + Zn(s) → Ni(s) + Zn2+(aq) | 1.0 V |
| c) | Ni2+(aq) + Zn(s) → Ni(s) + Zn2+(aq) | 0.52 V |
| d) | Zn2+(aq) + Ni(s) → Zn(s) + Ni2+(aq) | 1.0 V |
|  |  |  |

***Questions 6 and 7 refer to the information below.***

The table shows the data for four titrations carried out to determine the concentration of an unknown NaOH solution with 20.00 mL of standardised 0.2000 mol L–1 HCℓ solution using phenolphthalein as the indicator.

|  |  |
| --- | --- |
| **Trial** | **Volume of NaOH(aq) (mL)** |
| 1 | 19.26 |
| 2 | 19.35 |
| 3 | 19.15 |
| 4 | 19.30 |

**Question 6**

Which statement best accounts for the lower volume of NaOH(aq) in Trial 3?

(a) Some of the neutralised solution from Trial 2 was left in the conical flask for Trial 3.

(b) The pipette was rinsed with water before filling with hydrochloric acid.

(c) Three drops of phenolphthalein were used instead of two drops in the other trials.

(d) A few drops of NaOH solution spilled over the edge of the conical flask in Trial 3.

**Question 7**

Which one of the following is the correct volume (in mL) to use in calculating the NaOH concentration?

(a) 19.30

(b) 19.27

(c) 19.33

(d) 19.15

**Question 8**

Consider the incomplete chemical equation shown below.

Cr*(s)* + ClO3-*(aq)* + H+*(aq)* => Cr3+*(aq)* + HClO2*(aq)* + H2O*(l)*

When this redox reaction is completed and balanced correctly (using whole numbers), the coefficient in front of H+*(aq)* will be;

a) 1

b) 3

c) 6

d) 9

**Question 9**

Consider the following statements about galvanic and fuel cells.

1. The overall reaction is exothermic
2. Electrons are consumed at the negative electrode
3. Both the reducing agent and the oxidising agent are stored in each half-cell
4. The electrodes are in contact with the reactants and the electrolyte
5. The production of electricity requires the electrodes to be replaced regularly

Which of the following sets of statements are true for **both** galvanic and fuel cells.

1. Statements number 2 and 3
2. Statements number 1 and 4
3. Statements number 2, 4 and 5
4. Statements number 1, 3 and 5

**Question 10**

Which of the following pieces of equipment should be rinsed with the relevant chemical solution, rather than just distilled water, before using in an acid – base titration?

(i) burette

(ii) conical flask

(iii) pipette

(iv) volumetric flask

(a) i and ii only

(b) i and iii only

(c) i, iii and iv only

(d) i, ii and iv only

END OF PART ONE

PART TWO: SHORT RESPONSE (26 marks)

*Answer ALL questions in the spaces provided.*

**Question 11 (7 marks)**

a) The following chemical reaction describes the oxidation of ethanol to form acetaldehyde. Use oxidation numbers to determine which element is being oxidised and which is being reduced in this redox reaction. (3 marks)

**5CH3OH + 4MnO4- + 12H+ 🡪 5HCOOH + 4Mn2+ + 11H2O**

Oxidised: C -2 🡪 +2

Reduced: Mn 7+ 🡪 2+

(1 mark – all oxidation numbers correct, 1 mark each for correct oxidised and reduced substance)

1. Write the oxidation number of the underlined elements in the following chemical species?

SnCl4 +4

H3PO4 +5

C2O42- +3

NaH -1

(4 marks)

(1 mark for each one correct)

**Question 12 (6 marks)**

Tin is a metallic element located in Group 14 of the periodic table. It is used to make many different alloys such as bronze and solder, as well as finding application in the plating of steel to produce ‘tin cans’ for storage.

A chemistry student had 1.0 mol L-1 solutions of the following four substances;

Ni(NO3)2 Zn(NO3)2 Pb(NO3)2 Mg(NO3)2

1. Which of these solutions could not be stored in a tin container? Explain your answer using a relevant chemical equation.

(3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Pb(NO3)2 | **1** |
| Metal displacement reaction would occur OR Pb2+ had higher E0 value than Sn2+ and will cause oxidation of tin container | **1** |
| Pb2+(aq) + Sn(s) => Pb(s) + Sn2+(aq) | **1** |
| **Total** | **3** |

When tin metal is placed in an acidified solution containing the weak acid hydrogen chromate (HCrO4-) a deep green solution containing chromium (III) ions is formed, and the tin metal dissolves producing tin(II) ions.

1. Write the oxidation and reduction half-equations and the overall redox equation for this reaction.

(3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Oxidation half-equation  Sn(s) => Sn2+(aq) + 2e- | **1** |
| Reduction half-equation:  HCrO4-(aq) + 7H+ + 3e- => Cr3+(aq) + 4H2O(l) | **1** |
| Overall redox equation:  2HCrO4-(aq) + 14H+(aq) + 3Sn(s) => 2Cr3+(aq) + 3Sn2+(aq) + 8H2O(l) | **1** |
| **Total** | **3** |

**Question 13 (13 marks)**

An investigation into the oxidising strength of various metals was set up as shown below initially comparing copper and magnesium.



a) Label the anode and cathode. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Mg = anode and Cu = cathode | **1** |
| **Total** | **1** |

b) On the diagram, draw arrows which shows the flow of electrons through the cell.(1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Arrows from the magnesium towards the copper | **1** |
| **Total** | **1** |

c) Write the overall redox equation and calculate the cell voltage under standard conditions. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Cu2+(aq)  +  Mg(s)  →  Cu(s)  +  Mg2+(aq) | **1** |
| Cell voltage = + 2.02 V | **1** |
| **Total** | **2** |

d) Name suitable electrolyte solutions for each beaker. (2 marks)

Copper electrode beaker

Magnesium electrode beaker

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Magnesium: magnesium nitrate | **1** |
| Copper: copper nitrate | **1** |
| **Total** | **2** |

e) State two observations for the copper half–cell as the reaction proceeds. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Solution: became less blue | **1** |
| Electrode: became larger | **1** |
| **Total** | **2** |

As part of the experiment the student weighed both electrodes before and after the experiment and found one electrode increased by 0.253 g.

f) Calculate the mass change in the other electrode. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Identifies Cu electrode increases by 0.253 g | **1** |
| n(Cu) = 0.253 ÷ 63.55 = 0.00398 = n(Mg) | **1** |
| m(Mg) electrode change = 0.00398 × 24.31 = 0.096 g decrease (must state decrease) | **1** |
| **Total** | **3** |

g) Explain what a salt bridge is and outline its purpose as part of a galvanic cell. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A salt bridge is a folded up paper immersed in a salt such as ammonium nitrate | **1** |
| Its purpose is to complete the circuit by allowing the passage of ions between beakers. | **1** |
| **Total** | **2** |

END OF PART TWO

PART THREE: EXTENDED RESPONSE (14 marks)

*Answer all questions in the spaces provided. Full working must be shown for calculations. Final answers must be given to 3 significant figures.*

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 14 (7 marks)**

A group of students analysed a sample of white wine for acid content. The 20.00 mL aliquots of wine were titrated using a previously standardised 1.004 mol L–1 solution of sodium hydroxide. First the sodium hydroxide was diluted by pipetting 10.00 mL of the 1.004 mol L–1 solution into a 100.0 mL volumetric flask and then filling with distilled water to the mark.

The following burette readings were obtained using this diluted solution.

a) Complete the table below (2 marks)

|  |  |  |  |
| --- | --- | --- | --- |
| **Titration**  **number** | **Burette readings (mL)** | | |
| **Initial** | **Final** | **Titre** |
| 1 | 0.43 | 19.35 |  |
| 2 | 19.35 | 38.38 |  |
| 3 | 1.15 | 20.25 |  |
| 4 | 20.25 | 39.30 |  |
| 5 | 0.15 | 19.43 |  |
| **Average titre** | | |  |

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Calculates titres for each titration | **1** |
| Calculates average titration volume = 19.06 mL | **1** |
| **Total** | **2** |

b) Determine the concentration of diprotic tartaric acid (in g L–1) in a sample of white wine. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| [NaOH] dil = 1.004 x 10/100 = 0.1004 mol L–1 | **1** |
| n(NaOH) = 0.01906 x 0.1004 = 1.913 x 10–3 mol | **1** |
| n(tartaric acid) = ½ x n(NaOH) = 9.566 x 10–4 mol in 20 mL | **1** |
| [tartaric acid] = 9.566 x 10–4/0.02 = 0.04784 mol L–1 | **1** |
| c(tartaric acid) = 0.04784 x 150.088 = 7.179 g L–1 | **1** |
| **Total** | **5** |

**Question 15 (7 marks)**

The Haber Process is the commercial process designed by Fritz Haber in 1909 to produce ammonia. This occurs via the chemical reaction:

**N2(g) + 3H2(g) ⇌ 2NH3(g) ΔH = -92.4 kJmol-1**

The conditions for which this process operates are listed in the table below:

A picture containing text, screenshot, font, line

Description automatically generated

|  |  |
| --- | --- |
| **Condition:** | **Specification:** |
| Temperature: | 400-450oC |
| Pressure: | 200 atm |
| Catalyst: | Iron beds |

Nitrogen gas from the air is reacted with hydrogen gas which is produced through the hydrolysis of methane gas. This is performed in a closed system where any unreacted gases are recycled. This is shown in the flow diagram provided.

1. Explain why a moderate temperature of 400-450oC is used in the Haber process. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The Haber process is an exothermic reaction due to negative change in enthalpy | **1** |
| An increased temperature will reduce yield of ammonia. | **1** |
| Temperature increases reaction rate. | **1** |
| **Total** | **3** |

1. Explain why a high pressure of 200 atm is used. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increased pressure results in increased reaction rate | **1** |
| Increased pressure favours the reaction with the smallest number of moles | **1** |
| High pressure results in improved yield as forward reaction is favoured | **1** |
| **Total** | **3** |

1. What limitation is there on pressure? Why isn’t a higher pressure used? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| High cost of equipment to maintain high pressures | **1** |
| **Total** | **1** |

END OF PART THREE

END OF TEST

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

CHEMISTRY

Multiple Choice Answers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **1** | A | B | C | D |
| **2** | A | B | C | D |
| **3** | A | B | C | D |
| **4** | A | B | C | D |
| **5** | A | B | C | D |
| **6** | A | B | C | D |
| **7** | A | B | C | D |
| **8** | A | B | C | D |
| **9** | A | B | C | D |
| **10** | A | B | C | D |