**Question 7** *(9 marks, 13 minutes)*

Proteins are important biological compounds. The nitrogen content of a sample of dried protein, with a mass of 0.895 g, was determined by converting all the nitrogen in the protein into ammonia gas, NH3. The ammonia was then bubbled through 50.0 mL of 0.197 M HCl solution. A reaction occurred, as shown in the equation below.

NH3 (g) + HCl (aq) 🡒 NH4+ (aq) + Cl- (aq)

1. Calculate the initial number of moles of HCl present before the reaction with ammonia.

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*1 mark*

After the ammonia had reacted, excess HCl remained. The excess HCl was neutralised by titrating with 5.90 mL of 1.000 M NaOH. A reaction occurred, as shown in the equation below:

HCl (aq) + NaOH (aq) 🡒 NaCl (aq) + H2O (l)

1. Determine the number of moles of excess HCl.

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*3 marks*

1. Hence determine the number of moles of NH3 that reacted with the HCl solution.

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*2 marks*

1. Calculate the percentage mass of nitrogen in the sample of dried protein.

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*3 marks*

**Question 6**

During an acid/base titration of sodium carbonate solution and hydrochloric acid, the calculated value of the hydrochloric acid was found to be lower than its true value. This could be due to which of the following?

1. The student rinsed the pipette with water instead of the primary standard sodium carbonate solution.
2. The student filled the pipette with sodium carbonate solution so that the top of the meniscus was level with the calibration mark.
3. The conical flask used in the titration was rinsed with water.
4. The student overshot the endpoint of the titration.

**Question 1**

Zinc is often used to combine with copper to make the alloy, brass. This improves the properties of the copper for many applications. A 0.500 g sample of shavings of brass was treated with 100 mL of 0.150 M hydrochloric acid and the resulting solution was left to stand until the reaction had ceased. The acid reacts only with the zinc leaving the copper unreacted.

A 25.0 mL aliquot of the resulting solution was then titrated with 0.100 M sodium hydroxide solution and 23.4 mL of sodium hydroxide was required to neutralise the excess acid.

1. Write the overall, balanced equation for the reaction of the zinc with the acid.

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1. Why were shavings of brass used in the analysis?

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1. Calculate the amount, in mol, of sodium hydroxide used in the titration.

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1. Calculate the total amount, in mol, of HCl that reacted with the zinc in the original shavings of brass.

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1. Determine the percentage of the **copper** in the alloy?

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1. Would a 100 mL syringe be large enough in volume to collect the gas produced in the reaction at 25°C and 1.01 × 105 Pa? Explain your answer.

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1. Suggest an instrumental technique that could be used to verify the percentage of copper in the alloy. Briefly justify your response.

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**Question 1**

The level of carbon monoxide in a gaseous mixture can be measured by passing the gas over solid di-iodopentoxide. The iodine released can then be dissolved in water and titrated with sodium thiosulfate solution until the endpoint is reached when the solution becomes colourless. Starch solution may be used as an indicator to aid in the determination of the endpoint. The equations involved are

5 CO (g) + I2O5 (s) → I2 (s) + 5 CO2 (g)

I2 (aq) + 2 S2O32– (aq) → 2 I– (aq) + S4O62– (aq)

1. Write a balanced half equation showing the species acting as the reductant in the second equation.

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1. A 2.000 litre sample of air is analysed for the presence of carbon monoxide. If 22.43 mL of 0.0520 M thiosulfate solution is needed to titrate the iodine released, calculate the number of moles of iodine produced.

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1. Calculate the number of moles of carbon monoxide present in the sample of air.

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1. If the air is at SLC, calculate the volume of carbon monoxide in the sample and then the percentage of carbon monoxide in the sample.

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*1 + 2 + 1 + 2 = 6 marks*

**Question 4**

A 16.0 g sample of sodium hydroxide was dissolved in enough water to make up one litre of solution. A 20.0 mL aliquot of this solution was then titrated with 0.450 M hydrochloric acid. 18.5 mL of the acid was used to reach the endpoint of the reaction.

This data suggests that

1. the NaOH had absorbed water before being weighed out
2. the piptette used to transfer the dilute NaOH (aq) to the titration flask had been incorrectly rinsed with the acid solution
3. the burette had been incorrectly rinsed with the dilute sodium hydroxide solution
4. the titration flask had been rinsed with water prior to the aliquot of diluted NaOH (aq) being added

**Question 18**

All the glassware used during each titration was rinsed only with water and not dried. The effect of these rinsings on the calculated concentration of HCl would be that the calculated concentration

1. would be higher than the actual concentration
2. would be lower than the actual concentration
3. would be equal to the actual concentration
4. would be higher or lower than the actual concentration, depending on how much water remained in each piece of glassware

**Question 19**

The experiment was repeated, but this time the glassware used was correctly rinsed. During each of the repeated titrations, the endpoint was incorrectly taken to be when the solution turned red. The correct endpoint is the pink/orange colour that occurs before the red colour is reached. The effect of this error in endpoint determination would be that the calculated concentration of HCl

1. would be higher than the actual concentration
2. would be lower than the actual concentration
3. would be equal to the actual concentration
4. would be higher or lower than the actual concentration, depending on how red the solution had become at the endpoint







After standardisation, the concentration of the HCl was found to be 0.117 M. A mass of 7.71 g of *Grease-Buster* was weighed into a standard flask and made up to 250.0 mL with deionised water.

Aliquots of 20.00 mL of the diluted solution were titrated with the standardised HCl and the average titre was found to be 21.10 mL.

1. Calculate the amount in moles of HCl used.

*1 mark*

1. Calculate the amount in moles of NaOH in the original sample.

*1 mark*

1. Calculate the concentration of NaOH in *Grease-Buster* in %(w/w)

*1 mark*

***Total 10 marks***

**Question 1**

A basic solution is titrated with an acid using methyl orange indicator. The indicator colour changes from yellow when the pH drops below 4.4 and turns red when the pH drops below 3.1. Between 4.4 and 3.1, the indicator displays its orange ‘endpoint’ colour. By what factor does the [H3O+] in the titration flask change at the end point?

1. decrease by 1.3
2. decrease by 20
3. increase by 1.3
4. increase by 20

|  |  |  |
| --- | --- | --- |
| **1.** | **D** | Since the base is titrated with the acid, then the titration flask contains the base and the pH will drop as the acid is added. Therefore, at the endpoint the pH decreases from 4.4 to 3.1 pH 4.4 → [H3O+] = 10–4.4 = 3.98 × 10-5 pH 3.1 → [H3O+] = 10–3.1 = 7.94 × 10-4Therefore, at the endpoint the [H3O+] increases from 3.98 × 10-5 to 7.94 × 10-4,[H3O+] **increases by a factor of**  = **20** |

**Question 11**

A 0.01 M solution of a weak, monobasic base is titrated with a 0.01 M solution of a strong, monoprotic acid.

At the equivalence point of this titration, the pH of the reaction mixture will be

**A.** less than 7.

**B.** 7 exactly.

**C.** greater than 7.

**D.** less than or greater than 7 depending on the particular strong acid and weak base used.



**Question 2**

The volume, in mL, of 0.500 mol L-1 hydrochloric acid needed to titrate completely 25.0 mL of 0.350 mol L-1 barium hydroxide solution is

1. 8.75 mL
2. 17.5 mL
3. 25.0 mL
4. 35.0 mL









































