Questions

Q1.

10.0 cm^3 of a solution containing $Cu^{2+}(aq)$ ions was added to excess potassium iodide solution and the following reaction occurred.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

(a) What happens to the $Cu^{2+}(aq)$ during this reaction? Justify your answer.

(2)

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(b) All of the mixture containing iodine was titrated using sodium thiosulfate solution of concentration 0.200 mol dm^{-3}. The volume of sodium thiosulfate solution added at the end-point was 12.75 cm^3.

The equation for the reaction is

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow Na_2S_4O_6(aq) + 2NaI(aq)$$

(i) The end-point is shown most effectively using an indicator. State a suitable indicator and the colour change you would expect to see at the end-point.

(2)

Indicator

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Colour change at end-point

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(ii) Calculate the number of moles of iodine in the solution.

(2)

*(iii) Use your answer from (ii), and the equation for the reaction between $Cu^{2+}(aq)$ and $I^{-}(aq)$, to calculate the concentration of the $Cu^{2+}(aq)$ in the original sample of solution.

Give your answer to **three** significant figures and justify why this is an appropriate level of accuracy.

(3)

(iv) The whole of the solution containing iodine was used in one titration. Explain how this affects the reliability of your answer to (iii).

(1)

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(Total for question = 10 marks)

Q2.

Sodium burns in oxygen to give a pale yellow solid **X**.

(a) (i) 1.73 g of sodium reacts with 1.20 g of oxygen.
Calculate the empirical formula of **X**.

(2)

(ii) The molar mass of **X** is 78 g mol^{-1}. Give the molecular formula of **X**.

(1)

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(iii) Write the equation, including state symbols, for the reaction of sodium with oxygen to produce **X**.

(2)

(iv) Calculate the volume of oxygen in dm^3 (at room temperature and pressure) which reacts with 1.73 g of sodium. (The molar volume of any gas at room temperature and pressure is 24 dm^3 mol^{-1}.)

(2)

(v) Calculate the number of oxygen **molecules** that react with 1.73 g of sodium. (The Avogadro constant = 6.02×10^{23} mol^{-1}.)

(1)

(b) If sodium is burnt in **air**, compound **X** is not the only product. Suggest why this is so.

(1)

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(Total for question = 9 marks)

Q3.

Olive oil is an important edible oil. In many European countries, it is used as an alternative to butter for spreading on bread.

A useful method of comparing fats and oils is to measure their iodine values. An iodine value is the amount of iodine in grams that reacts with 100 g of a fat or oil.
This measures the degree of unsaturation of the fat or oil.

The iodine value of olive oil can be determined in the following way.

Add 0.200 g of olive oil to a 250 cm^3 conical flask.

Add 10 cm^3 of solvent to dissolve the oil.

Add 10.0 cm^3 of a solution of iodine monochloride, called Wijs solution.

Stopper the flask and allow to stand in the dark for half an hour.

Add 15 cm^3 of 10% potassium iodide solution and 100 cm^3 of water and shake the mixture.

Titrate the liberated iodine with 0.100 mol dm^{-3} sodium thiosulfate solution. This is the sample titre.

Carry out a blank titration using 10 cm^3 of solvent, 10.0 cm^3 of Wijs solution, 15 cm^3 of 10% potassium iodide solution and 100 cm^3 of water.

(a) For many years, 1,1,1-trichloroethane was used as the solvent for this reaction.

(i) Draw the **displayed** formula for 1,1,1-trichloroethane.

(1)

(ii) Suggest why the solvent 1,1,1-trichloroethane is no longer used.

(1)

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(b) (i) Iodine monochloride adds more readily than iodine to carbon-carbon double bonds. Using your knowledge of electrophilic addition, suggest why this is so.

(1)

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(ii) Complete the formula of the product formed when iodine monochloride, ICl, reacts with oleic acid, $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$, the most abundant unsaturated compound in olive oil.

(1)

$$CH_3(CH_2)_7—C—C—(CH_2)_7COOH$$

(iii) Suggest why the mixture must be kept in the dark.

(1)

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.....

(iv) Give the oxidation numbers of iodine in iodine monochloride, iodide ions and iodine.
Write the ionic equation for the reaction between iodide ions and iodine monochloride. State symbols are not required.

(2)

Oxidation number of iodine in

Iodine monochloride .....

Iodide ion .....

Iodine .....

Ionic equation for this reaction

(c) Suggest a suitable indicator for the titration. Give the colour change of the solution at the end point.

(2)

Indicator

.....

Colour change from

..... to .....

(d) In the blank titration, 20.0 cm^3 of sodium thiosulfate solution reacted with 10.0 cm^3 of Wijs solution.

(i) Calculate the number of moles of 0.100 mol dm^{-3} sodium thiosulfate that reacted with the **blank** titre.

(1)

(ii) Complete the ionic equation for the reaction between iodine and thiosulfate ions. Include state symbols.

(1)

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow$

(iii) Calculate the number of moles of iodine, I_2, that reacted with the thiosulfate solution in the blank titration.

(1)

(iv) Using your answers to (b)(iv) and (d)(iii), write down the corresponding number of moles of iodine monochloride solution in 10 cm^3 of Wijs solution.

(1)

(v) The number of moles of iodine monochloride left after reacting the Wijs solution with the olive oil sample, calculated from the sample titre, is 3.65×10^{-4} mol.

Use this, and your answer to (d)(iv), to calculate the amount of iodine monochloride that reacted with the sample.

(1)

(vi) Your answer to (d)(v) is equal to the number of moles of iodine that would have reacted with 0.200 g of olive oil.

Calculate the number of moles of iodine that would have reacted with 100 g of olive oil.

(1)

(vii) Calculate the mass of iodine, I_2, that would have reacted with 100 g of olive oil, which is the iodine value for the olive oil.

(1)

(e) Butter contains a smaller percentage of unsaturated molecules than olive oil.

Would the titre value and iodine value for butter be higher, lower or about the same as the values for olive oil?

(1)

Sample titre

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Iodine value

.....

(Total for question = 17 marks)

Q4.

(a) Coral reefs are produced by living organisms and predominantly made up of calcium carbonate. It has been suggested that coral reefs will be damaged by global warming because of the increased acidity of the oceans due to higher concentrations of carbon dioxide.

(i) Write a chemical equation to show how the presence of carbon dioxide in water results in the formation of carbonic acid. State symbols are **not** required

(1)

(ii) Write the **ionic** equation to show how acids react with carbonates. State symbols are **not** required.

(2)

(b) One method of determining the proportion of calcium carbonate in a coral is to dissolve a known mass of the coral in excess acid and measure the volume of carbon dioxide formed.

In such an experiment, 1.13 g of coral was dissolved in 25 cm^3 of hydrochloric acid (an excess) in a conical flask. When the reaction was complete, 224 cm^3 of carbon dioxide had been collected over water using a 250 cm^3 measuring cylinder.

(i) Draw a labelled diagram of the apparatus that could be used to carry out this experiment.

(2)

(ii) Suggest how you would mix the acid and the coral to ensure that no carbon dioxide escaped from the apparatus.

(1)

(iii) Calculate the number of moles of carbon dioxide collected in the experiment.

[The molar volume of any gas is 24 000 $cm^3\ mol^{-1}$ at room temperature and pressure.]

(1)

(iv) Complete the equation below for the reaction between calcium carbonate and hydrochloric acid by inserting the missing state symbols.

(1)

$CaCO_3$(.....) + 2HCl(.....) → $CaCl_2$(.....) + H_2O(l) + CO_2(.....)

(v) Calculate the mass of 1 mol of calcium carbonate.

[Assume relative atomic masses: Ca = 40, C = 12, O = 16.]

(1)

(vi) Use your data and the equation in (iv) to calculate the mass of calcium carbonate in the sample and the percentage by mass of calcium carbonate in the coral.

Give your final answer to **three** significant figures.

(2)

(vii) When this experiment is repeated, the results are inconsistent. Suggest a reason for this other than errors in the procedure, measurements or calculations.

(1)

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(Total for question = 12 marks)

Q5.

Dave wanted to find the concentration of ethanoic acid in some vinegar he found in his cupboard.

His method is as follows:

a) He carefully measures out $50cm^3$ of the vinegar solution.
b) He reacts this with $10cm^3$ of NaOH (concentration 5 $moldm^3$) (this is an excess)
c) He takes the resulting solution and adds distilled water until the total volume is $250cm^3$
d) He then carefully measures out $25cm^3$ of the new solution and place in a flask with a few drops of indicator.
e) Using a burette, he then titrates the mixture in the flask with $0.2moldm^{-3}$ HCl.
f) Like any good chemist, Dave repeats step (e) until he gets consistent results. His average volume of HCl is $22.45cm^3$.

What is the concentration of ethanoic acid in the vinegar solution? (7)

(if this is a bit too full on, then on the next page I have broken down the calculation into the steps you should do, but see if you can work it out without first!!! :))

Steps:

- How many moles of HCl were used in the titration?
- How many moles of NaOH were used in the titration?
- How many moles of NaOH were in the 250cm^3?
- How many moles of NaOH were added in the first place?
- How many moles of NaOH reacted with the ethanoic acid?
- How many moles of ethanoic acid were there in 50cm^3?
- What is the concentration of the ethanoic acid?