Session 3

Q1, 9701/33/F/M/17

1. The concentration of hydrogen peroxide may be given in $mol dm^{-3}$ or as 'volume strength'. You will determine the concentration of hydrogen peroxide in $mol dm^{-3}$ and in 'volume strength' by a gas collection method.

   Hydrogen peroxide decomposes to form water and oxygen. The reaction is much faster in the presence of a catalyst such as manganese (IV) oxide.

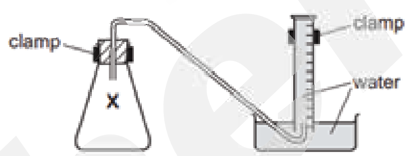
   $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

   'Volume strength' is defined as the volume of oxygen in cm^3 produced from the decomposition of $1.0 cm^3$ of hydrogen peroxide at room temperature and pressure. For example, $1.0 cm^3$ of '100 volume' hydrogen peroxide will produce $100 cm^3$ of oxygen.

   FA 1 is a solution of hydrogen peroxide, H_2O_2.
   FA 2 is manganese (IV) oxide, MnO_2.

   (a) Method

   Read the whole method before starting any practical work.
   The diagram below may help you in setting up your apparatus.



- Fill the tub with water to a depth of about 5cm.
- Fill the $250 cm^3$ measuring cylinder completely with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so that the open end is in the water just above the base of the tub.
- Rinse the $50 cm^3$ measuring cylinder with a little FA 1 then use it to transfer $150 cm^3$ of FA 1 into the reaction flask labelled X.
- Check that the bung fits tightly in the neck of flask X, clamp flask X and place the end of the delivery tube into the inverted $250 cm^3$ measuring cylinder.

- Remove the bung from the neck of the flask. Tip FA 2 into the hydrogen peroxide and replace the bung immediately. Remove the flask from the clamp and swirl it to mix the contents. Swirl the flask occasionally until no more gas is given off. Replace the flask in the clamp.
- Measure and record the final volume of gas in the measuring cylinder in the space below.

Keep FA 1 for use in Question 2.

Result

[2]

(b) Calculations
Show your working and appropriate significant figures in the final answer to each step of your calculations.

(i) Use the information on page 2 to calculate the 'volume strength' of FA 1.

'volume strength' of FA 1 = ...

(ii) Calculate the number of moles of oxygen collected in the measuring cylinder. [Assume 1 mole of gas occupies $24.0dm^3$ under these conditions.]

moles of O_2 = ... mol

(iii) Using your answer to (ii) calculate the number of moles of hydrogen peroxide in the volume of FA 1 added to flask X.

moles of H_2O_2 = ... mol

(iv) Calculate the concentration of hydrogen peroxide, FA 1, in $moldm^{-3}$.

concentration of H2O2, FA 1 = ... $moldm^{-3}$

[4]

(c)

(i) A source of error in this experiment is that some oxygen escapes before the bung can be inserted.

Suggest a change to the practical procedure given in (a) to reduce this source of error. You may draw a diagram as part of your answer.

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(ii) The error in reading a 50cm^3 measuring cylinder is 0.5cm^3. Calculate the maximum percentage error in the volume of hydrogen peroxide added to flask X in (a).

maximum percentage error in volume of H_2O_2 = ... %

(iii) Explain why the presence of 20cm^3 of air in the 250cm^3 measuring cylinder before the start of the experiment would decrease the accuracy of the results obtained in (a).

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....

[4]

(d) If you repeated the method described using half the mass of FA 2, what volume of gas would you expect to collect? Explain your answer.

....

....

[1]

[Total: 11]

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Q2, 9701/33/M/J/20

2. When an organic acid, RCOOH, is neutralised by an alkali an exothermic reaction takes place. You will determine the enthalpy change of neutralisation, ΔH, for the following reaction.

$$RCOOH(aq) + NaOH(aq) \rightarrow RCOONa(aq) + H_2O(l)$$

In this equation R is an alkyl group.

FA 3 is a solution containing 120.1gdm^{-3} of RCOOH.
FA 4 is aqueous sodium hydroxide, NaOH.

(a) Method

Experiment 1

- Support the cup in the 250cm^3 beaker.
- Use the 25cm^3 measuring cylinder to transfer 25.0cm^3 of FA 3 into the cup.
- Measure and record the temperature of this FA 3. Rinse the thermometer.
- Place 25.0cm^3 of FA 4 into the 50cm^3 measuring cylinder.
- Measure and record the temperature of the FA 4 in the measuring cylinder. Rinse the thermometer.
- Tip the FA 4 from the measuring cylinder into the cup. Stir, then measure and record the highest temperature reached.
- Calculate and record the average initial temperature of FA 3 and FA 4.
- Calculate and record the difference between the average initial temperature and the highest temperature reached.
- Rinse and dry the cup for use in Experiment 2.

Experiment 2

- Repeat Experiment 1 using 50.0cm^3 of FA 3 and FA 4. You will need to use the 25cm^3 measuring cylinder twice to measure the FA 3.
- Calculate and record the average initial temperature of FA 3 and FA 4.
- Calculate and record the difference between the average initial temperature and the highest temperature reached.

[4]

3.

(b) Calculations

(i) Calculate the energy released in Experiment 1. (Assume that 4.2J of energy changes the temperature of 1.0cm^3 of solution by 1.0°C.)

energy released = ... J

[1]

(ii) (ii) Calculate the number of moles of RCOOH used in Experiment 1. Assume that the relative molecular mass, Mr, of RCOOH is 122. Show your working.

moles of RCOOH = ... mol

[2]

(iii) (iii) Calculate the enthalpy change of neutralisation, ΔH, of RCOOH. Assume that the sodium hydroxide is in excess.

enthalpy change of neutralisation of RCOOH = ... kJmol^{-1} sign value

[1]

(c) Each measuring cylinder can be read to an accuracy of ± 0.5cm^3.

Calculate the total maximum percentage error in the volumes of solution measured in each of Experiments 1 and 2.

Experiment 1

total maximum percentage error = ... %

Experiment 2

total maximum percentage error = ... %

[2]

(d) A student repeated both experiments in (a) using hydrochloric acid in place of RCOOH.

Suggest how the temperature rise when using HCl would compare to the temperature rise recorded in (a). Assume all volumes and concentrations of solutions, in moldm^{-3}, are the same.

Explain your answer by considering the chemical bonds involved.

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[2]

[Total: 12]