1.2 Reacting Masses & Volumes

Question Paper

Course	DP IB Chemistry
Section	1. Stoichiometric Relationships
Topic	1.2 Reacting Masses & Volumes
Difficulty	Hard

Time allowed: 60

Score: /48

Percentage: /100

Question 1a

a)
Citric acid, $C_6H_8O_7$, is present in lemon juice and is classed as a weak acid. 10.00 cm^3 of citric acid is reacted with sodium hydroxide, NaOH (aq), with a concentration of 12.0 g dm^{-3} to form sodium citrate, $Na_3C_6H_5O_7$, and water. 32.10 cm^3 of sodium hydroxide was required to react with the lemon juice.

State the balanced equation for this reaction.

[1]

[1 mark]

Question 1b

b)
Calculate the mass, in grams, of sodium hydroxide that reacted with the lemon juice.

[1]

[1 mark]

Question 1c

c)
Determine the concentration, in mol dm^{-3}, of citric acid in the sample of lemon juice.

[3]

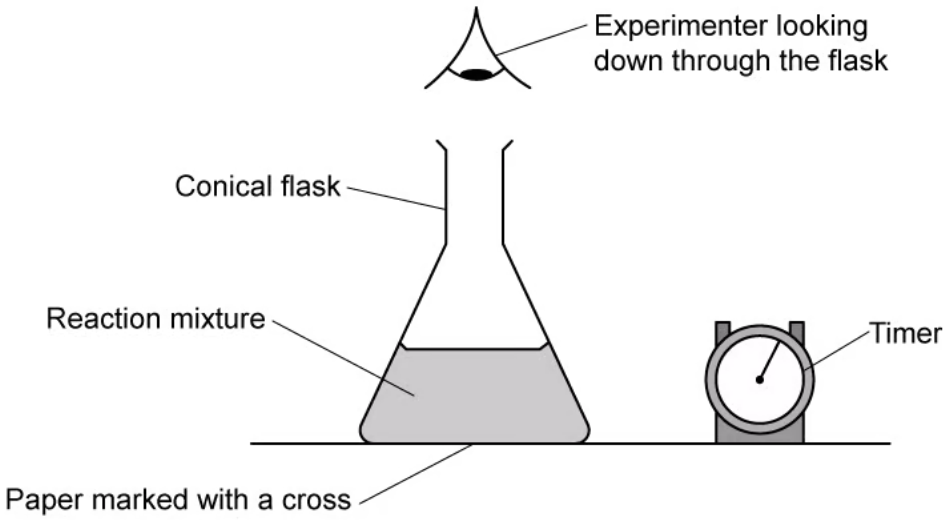
[3 marks]

Question 2a

a)

A group of students investigated the rate of reaction between sodium thiosulfate and hydrochloric acid by measuring the amount of time taken for a cross marked on a piece of paper to become obscured by a yellow precipitate.

$$Na_2S_2O_3\,(aq) + 2HCl\,(aq) \rightarrow 2NaCl\,(aq) + SO_2\,(g) + H_2O\,(l) + S\,(s)$$



Initially they measured out 15.00 cm^3 of 0.900 mol dm^{-3} hydrochloric acid and then added 40.00 cm^3 of 0.0150 mol dm^{-3} aqueous sodium thiosulfate.

The mark on the paper was obscured 38 seconds after the solutions were mixed.

Their teacher made up 3.00 dm^3 of sodium thiosulfate solution using sodium thiosulfate pentahydrate crystals, $Na_2S_2O_3 \bullet 5H_2O$.

Calculate the required mass, in grams, of these crystals. Give your answer to 2 decimal places.

[3]

[3 marks]

Question 2b

b)
Using section 2 of the Data booklet, calculate the volume of gas produced, in dm^3, in this reaction if it were collected at a temperature of 300 K and 1.00×10^5 Pa.

[4]

[4 marks]

Question 2c

c)
A different group of students decided to measure the rate of reaction by collecting the volume of sulfur dioxide produced over a period of time.

The students attempted to collect the gas in a measuring cylinder over water, but were unsuccessful. Suggest why they were unsuccessful.

[1]

[1 mark]

Question 2d

d)
Determine the pH of the acid used and suggest how pH could be used to measure the rate of reaction.

[2]

[2 marks]

Question 2e

e)
Determine the reagent in excess in this reaction and state the amount, in moles, that will be in excess.

[3 marks]

Question 3a

a)
Phosphine, PH_3, is a gas formed by heating phosphorous acid, H_3PO_3, in the absence of air, as shown in the equation below.

$$4H_3PO_3\,(s) \rightarrow PH_3\,(g) + 3H_3PO_4\,(s)$$

3.45×10^{-2} mol of H_3PO_3 is completely decomposed by this reaction.

State the expected molecular shape and expected bond angle in $PH_3\,(g)$.

[1]

[1 mark]

Question 3b

b)
Calculate the volume of phosphine gas formed, in cm^3, at 100 kPa pressure and 210 °C.

[5]

[5 marks]

Question 3c

c)
1.85 g of white phosphorus was used to make phosphine according to the equation.

$$P_4(s) + 3OH^-(aq) + 3H_2O(l) \rightarrow PH_3(g) + 3H_2PO_2^-(aq)$$

This phosphorus was reacted with 75.00 cm^3 of 4.50 mol dm^{-3} sodium hydroxide solution. Deduce, showing your working, which was the limiting reagent.

[3]

[3 marks]

Question 3d

d)
Using section 2 of the Data booklet determine the volume of phosphine, measured in cm^3 at standard temperature and pressure, that was produced. Give your answer to 3 significant figures.

[1]

[1 mark]

Question 4a

a)

A student carried out an experiment involving a solution of potassium dichromate(VI), $K_2Cr_2O_7$, with iron(II) sulfate, to find the mass of $FeSO_4.7H_2O$ in an impure sample, **A**.

The student recorded the mass of **A**, dissolved the sample in water and then made the solution up to 500 cm^3. After an excess was added, the student found that 25.00 cm^3 of this solution reacted with 22.10 cm^3 of a 0.020 mol dm^{-3} solution of $K_2Cr_2O_7$.

Deduce the full equation for the reaction between acidic $Cr_2O_7^{2-}(aq)$ and $Fe^{2+}(aq)$ to form $Cr^{3+}(aq)$ and $Fe^{3+}(aq)$.

[2]

[2 marks]

Question 4b

b)

Use section 6 of the Data booklet to determine the mass, in grams, of $FeSO_4.7H_2O$ in sample, **A.** Give your answer to three significant figures.

[4]

[4 marks]

Question 4c

c)
A student performs a titration to determine the molar mass and structure of a dicarboxylic acid, **X**, which only contains carbon, hydrogen and oxygen.

The student prepares a 250.0 cm^3 solution from 1.513 g of X.

The solution of X is added to the burette and titrated with 25.00 cm^3 aliquot of 0.112 mol dm^{-3} NaOH (aq).

The student recorded their results in the table below:

	Titration 1	**Titration 2**	**Titration 3**
Final burette reading / cm^3	28.60	27.95	29.45
Initial burette reading / cm^3	1.10	0.70	2.10
Volume added / cm^3	27.50	27.25	27.35

i)
Determine the mean volume, in dm^3, of the titre.

[1]

ii)
Determine the amount, in moles, of **X** in the original sample.

[3]

[4 marks]

Question 4d

d)
Using section 6 in the Data booklet, suggest a structure for **X**.

[2]

[2 marks]

Question 5a

a)

An empty 1.5 dm^3 Tupperware container has been kept in the fridge without a lid at 5 °C. The container is removed from the fridge and allowed to reach a temperature of 21 °C. Using your knowledge of Charles's Law, determine the volume of gas, in cm^3, that escaped from the container.

[4]

[4 marks]

Question 5b

b)

A balloon contains 2500 mL of helium gas at a temperature of 75 °C. Determine the new volume in mL of the gas when the temperature changes to 55 °C assuming the pressure is constant. Give your answer to three significant figures.

[2]

[2 marks]

Question 5c

c)

A 10.0 L container of helium gas with a pressure of 33 000 Pa at 0 °C is heated until the new pressure is 200 000 Pa. Determine the new temperature of the gas assuming the volume remains constant.

[2]

[2 marks]