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CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	AMOUNT OF SUBSTANCE
PAPER TYPE:	QUESTION PAPER 4
TOTAL QUESTIONS	10
TOTAL MARKS	51

Amount of Substance

1. A student does an experiment to determine the percentage by mass of sodium chlorate(I), NaClO, in a sample of bleach solution.
Method:

- Dilute a 10.0 cm^3 sample of bleach solution to 100 cm^3 with distilled water.
- Transfer 25.0 cm^3 of the diluted bleach solution to a conical flask and acidify using sulfuric acid.
- Add excess potassium iodide to the conical flask to form a brown solution containing $I_2(aq)$.
- Add 0.100 mol dm^{-3} sodium thiosulfate solution ($Na_2S_2O_3$) to the conical flask from a burette until the brown solution containing $I_2(aq)$ becomes a colourless solution containing I^- (aq).

The student uses 33.50 cm^3 of sodium thiosulfate solution.
The density of the original bleach solution is 1.20 g cm^{-3}
The equations for the reactions in this experiment are

ClO^- (aq) + $2H^+$ (aq) + $2I^-$ (aq) → Cl^- (aq) + H_2O(l) + I_2(aq)

$2S_2O_3^{2-}$ (aq) + I_2(aq) → $2I^-$ (aq) + $S_4O_6^{2-}$ (aq)

(a) Use all the information given to calculate the percentage by mass of NaClO in the original bleach solution.
Give your answer to 3 significant figures.

(7)

(b) The total uncertainty from two readings and an end point error in using a burette is ± 0.15 cm^3

What is the total percentage uncertainty in using the burette in this experiment?

A. 0.45%
B. 0.90%
C. 1.34%
D. 1.99%

(1)

2. The equation below represents the complete combustion of butane.

C_4H_{10} (g) + 6.5O_2 (g) → 4CO_2 (g) + 5H_2O (g)

20 cm^3 of butane are completely burned in 0.20 dm^3 of oxygen.
Which statement is correct?

All volumes are measured at the same temperature and pressure.

A. 40 cm^3 of carbon dioxide are formed
B. 0.065 dm^3 of oxygen react
C. 70 cm^3 of oxygen remain
D. 0.50 dm^3 of steam are formed

(Total 1 mark)

3. The heat released when 1.00 g of ethanol (Mr = 46.0) undergoes complete combustion is 29.8 kJ

I am Sorry !!!!

What is the heat released by each molecule, in joules, when ethanol undergoes complete combustion?

(The Avogadro constant L = 6.022 × 10^{23} mol^{-1})

A. 2.28×10^{-18} J
B. 4.95×10^{-20} J
C. 2.28×10^{-21} J
D. 4.95×10^{-23} J

(Total 1 marks)

4. This question is about sodium fluoride (NaF).

Some toothpastes contain sodium fluoride. The concentration of sodium fluoride can be expressed in parts per million (ppm).

1 ppm represents a concentration of 1 mg in every 1 kg of toothpaste.

(a) A 1.00 g sample of toothpaste was found to contain 2.88×10^{-5} mol of sodium fluoride.

Calculate the concentration of sodium fluoride, in ppm, for the sample of toothpaste.
Give your answer to 3 significant figures.

(4)

(b) Sodium fluoride is toxic in high concentrations. Major health problems can occur if concentrations of sodium fluoride are greater than 3.19×10^{-2} g per kilogram of body mass.

Deduce the maximum mass of sodium fluoride, in mg, that a 75.0 kg person could swallow without reaching the toxic concentration.

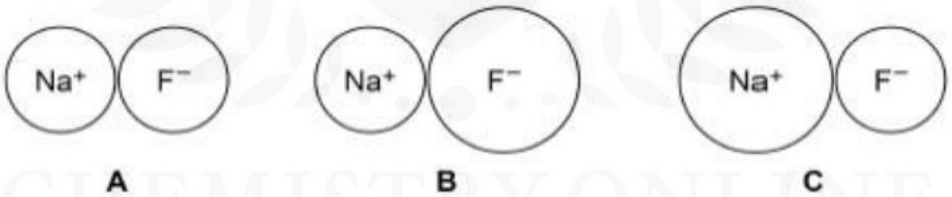
(1)

(c) The concentration of sodium fluoride in a prescription toothpaste is 2800 ppm.

Use your answer to Question (b) to deduce the mass of toothpaste, in kg, that a 75.0 kg person could swallow without reaching the toxic concentration.

(1)

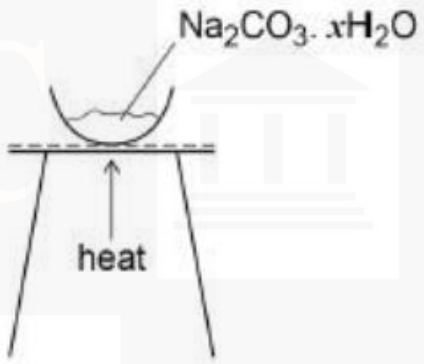
(d) Identify the diagram in the figure below that shows the correct relative sizes of the ions in sodium fluoride.



Justify your answer.

(3)

5. A student heated a solid sample of $Na_2CO_3.\ xH_2O$ for 1 minute to remove water and determine a value for x The diagram shows the apparatus used.



The table shows the results recorded.

Mass of empty evaporating basin	24.35 g
Mass of evaporating basin and solid before heating	25.47 g
Mass of evaporating basin and solid after heating for 1 minute	24.92 g

(a) Use the data in the table to calculate a value for x in the formula $Na_2CO_3.\ xH_2O$ Give your answer to 2 decimal places.

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(5)

(b) The correct value for x is 10. Suggest a reason for the difference between the experimental value for x and the correct value.

(If you were unable to calculate an experimental value for x assume it was 8.05. This is not the correct experimental value.)

(1)

(c) Suggest how the procedure could be improved, using the same apparatus, to give a more accurate value for x Justify your answer.

(2)

6. A student determined the relative molecular mass, Mr, of an unknown volatile liquid Y in an experiment as shown in the diagram.

The student used a hypodermic syringe to inject a sample of liquid Y into a gas syringe in an oven.
At the temperature of the oven, liquid Y vaporised.
The student's results are shown in the table.

Mass of hypodermic syringe and liquid Y before injection	10.91 g
Mass of hypodermic syringe and liquid Y after injection	10.70 g
Oven temperature	98.1 °C

Atmospheric pressure	102 kPa
Increase in volume in gas syringe after injection of Y	85.0 cm^3

(a) Define the term relative molecular mass (Mr).
Use the experimental results in the table to determine the relative molecular mass of Y.
The gas constant R = 8.31 J K^{-1} mol^{-1}

(5)

(b) Some of the liquid injected did not evaporate because it dripped into the gas syringe nozzle outside the oven.

Explain how this would affect the value of the Mr of Y calculated from the experimental results.

(2)

7. How many protons are there in 6.0 g of nitrogen gas?
Avogadro constant, L = 6.022 × 10^{23} mol^{-1}

A. 1.3 × 10^{23}
B. 9.0 × 10^{23}
C. 1.8 × 10^{24}

D. 3.6×10^{24}

(Total 1 mark)

8. A 30 cm^3 sample of nitrogen was reacted with a 60 cm^3 sample of fluorine according to the equation

What is the volume of the gas mixture after the reaction, at constant temperature and pressure?

A. 20 cm^3
B. 30 cm^3
C. 40 cm^3
D. 50 cm^3

(Total 1 mark)

9. Citric acid, $C_3H_5O(COOH)_3$, occurs naturally in many fruits and can also be synthesised in the laboratory for use as a food flavouring.

A student analysed a sample of citric acid to determine its percentage purity.
The student dissolved 784 mg of impure citric acid in water to prepare 250 cm^3 of solution in a volumetric flask.

The student titrated 25.0 cm^3 samples of this solution with 0.0500 mol dm^{-3} sodium hydroxide solution using phenolphthalein as the indicator.

$C_3H_5O(COOH)_3(aq) + 3NaOH(aq) \rightarrow C_3H_5O(COO)3Na_3(aq) + 3H_2O(l)$

(a) The student rinsed the burette before filling it with the sodium hydroxide solution.
State why the student should use sodium hydroxide solution rather than water for the final rinse of the burette.

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(1)

(b) The student carried out several titrations. The results are shown in the table.

Complete the table to show the titre in each titration.

Titration	Rough	1	2	3
Final reading / cm^3	25.2	23.95	47.65	24.10
Start reading / cm^3	0.0	0.05	23.95	0.10
Titre / cm^3				

(1)

(c) Calculate the mean titre using the concordant results.
Give your answer to the appropriate number of significant figures.

(2)

(d) The total uncertainty when using the burette is ±0.15 cm^3.
This is the combination of uncertainties in the start reading, final reading and the determination of the end point.

Use your answer to part (c) to calculate the percentage uncertainty for the use of the burette in this experiment.

(1)

(e) Use your answer to part (c) to find the mass, in mg, of citric acid dissolved in 250 cm^3 of the solution.
The relative molecular mass (Mr) of citric acid is 192.0

(3)

(f) Calculate the percentage purity of this sample of citric acid.

(1)

10. A student added 627 mg of hydrated sodium carbonate ($Na_2CO_3.xH_2O$) to 200 cm^3 of 0.250 mol dm^{-3} hydrochloric acid in a beaker and stirred the mixture.

After the reaction was complete, the resulting solution was transferred to a volumetric flask, made up to 250 cm^3 with deionised water and mixed thoroughly.

Several 25.0 cm^3 portions of the resulting solution were titrated with 0.150 mol dm^{-3} aqueous sodium hydroxide.

The mean titre was 26.60 cm^3 of aqueous sodium hydroxide.
Calculate the value of x in $Na_2CO_3.xH_2O$ Show your working.

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(Total 7 marks)

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