CHEMISTRY ONLINE TUITION

CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	AMOUNT OF SUBSTANCE
PAPER TYPE:	QUESTION PAPER 3
TOTAL QUESTIONS	10
TOTAL MARKS	47

Amount of Substance

1. This question is about a toxic chloroalkane, X, that has a boiling point of 40 °C.

A student carried out an experiment to determine the Mr of X by injecting a sample of X from a hypodermic syringe into a gas syringe in an oven at 97 °C and 100 kPa.

The student's results are set out in Table 1 and Table 2.

Table 1

Mass of hypodermic syringe filled with X before injection / g	10.340
Mass of hypodermic syringe with left over X after injection / g	10.070
Mass of X injected / g	

Table 2

Volume reading on gas syringe before injection of X / cm^3	0.0
Volume of X in gas syringe after injection of X / cm^3	105.0
Volume of X / cm^3	

(a) Complete Table 1 and Table 2 by calculating the mass and volume of X.

(1)

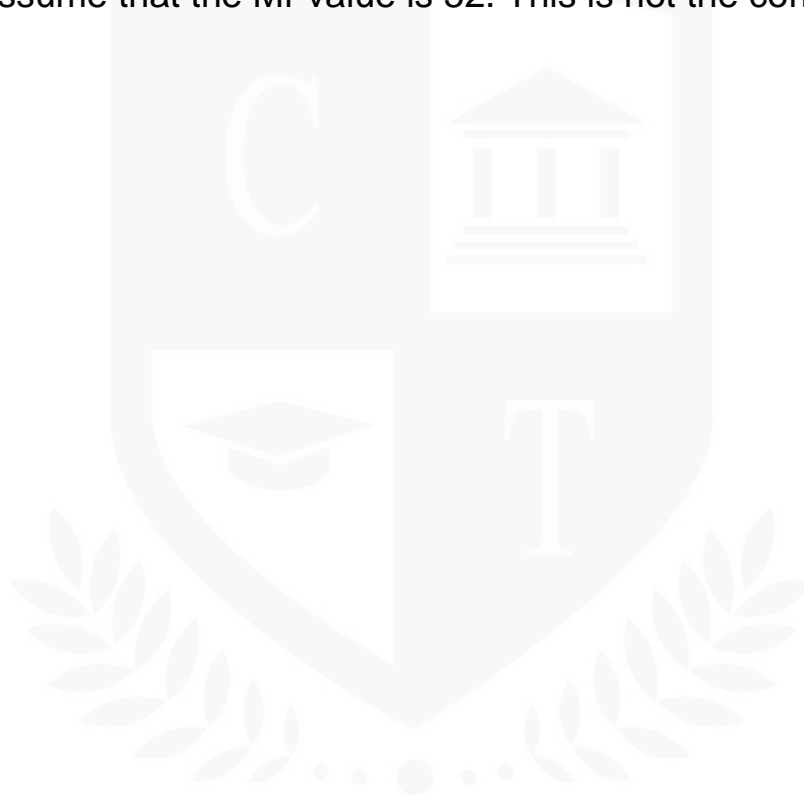**(b)** X is known to be one of the following chloroalkanes:

- CCl_4
- $CHCl_3$
- CH_2Cl_2
- CH_3Cl

Justify this statement by calculating a value for the Mr of X and use your answer to suggest the most likely identity of X from this list.

Give your answer for the Mr of X to an appropriate precision.

(The gas constant R = 8.31 J K^{-1} mol^{-1})

Identity of X (If you have been unable to calculate a value for Mr, you may assume that the Mr value is 52. This is not the correct value).

(5)

(c) Suggest a reason, other than apparatus inaccuracy, why the Mr value determined from the experimental results differs from the actual Mr.

(2)

(d) Suggest, with a reason, an appropriate safety precaution that the student should take when using the toxic chloroalkane, X, in the experiment.

(2)

2. What is the volume of 0.200 mol dm^{-3} Ba(OH)$_2$ (aq) required to neutralise exactly 30.0 cm^3 of 0.100 mol dm^{-3} HCl(aq)?

A. 150.0 cm^3
B. 75.0 cm^3
C. 15.0 cm^3
D. 7.50 cm^3

(Total 1 mark)

3. A student added 820 mg of hydrated magnesium sulfate (MgSO$_4$.zH$_2$O) to 180 cm^3 of 0.350 mol dm^{-3} nitric 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 225 cm^3 with distilled water and mixed thoroughly.

Several 30.0 cm^3 portions of the resulting solution were titrated with 0.180 mol dm^{-3} aqueous potassium hydroxide.

The mean titre was 22.15 cm^3 of aqueous potassium hydroxide.
Calculate the value of z in MgSO$_4$.zH$_2$O.
Show your working.

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(Total 6 marks)

4. The maximum errors for the pipette and the burette are shown below. These errors take into account multiple measurements.

Pipette ± 0.05 cm^3
Burette ± 0.15 cm^3

Estimate the maximum percentage error in using each of these pieces of apparatus.

Use an average titre 24.25 cm^3 to calculate the percentage error in using the burette.

(Total 2 marks)

5. Zinc is similar to Group 2 metals and forms compounds containing Zn^{2+} ions.

Write an equation for the thermal decomposition of zinc carbonate to zinc oxide.

Calculate the percentage atom economy for the formation of zinc oxide from zinc carbonate in this reaction.

(Total 3 marks)

6. Copper can be produced from rock that contains $CuFeS_2$

(a) Balance the equations for the two stages in this process.

.....$CuFeS_2$ + ...$O2$ + ...SiO_2 → .....Cu_2S + ...Cu_2O + ...SO_2 + ...$FeSiO_3$

.....Cu_2S + ...Cu_2O → .....Cu + ...SO_2
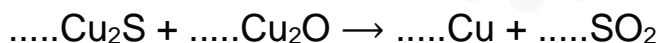
(2)

(b) Suggest two reasons why the sulfur dioxide by-product of this process is removed from the exhaust gases.
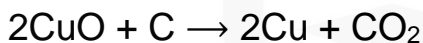
(2)

(c) A passenger jet contains 4050 kg of copper wiring. A rock sample contains 1.25% $CuFeS_2$ by mass.

Calculate the mass, in tonnes, of rock needed to produce enough copper wire for a passenger jet.
(1 tonne = 1000 kg)

(4)

(d) Copper can also be produced by the reaction of carbon with copper(II) oxide according to the equation

$2CuO + C \rightarrow 2Cu + CO_2$

Calculate the percentage atom economy for the production of copper by this process.

Give your answer to the appropriate number of significant figures.

(2)

7. Which of these contains the greatest number of atoms?

A. 127 mg of iodine
B. 1.54×10^{-4} kg of phosphorus
C. 81.0 mg of carbon dioxide
D. 1.70×10^{-4} kg of ammonia

(Total 1 mark)

8. A 20.0 cm^3 sample of a 0.400 mol dm^{-3} aqueous solution of a metal bromide (MBr$_n$) reacts exactly with 160 cm^3 of 0.100 mol dm^{-3} aqueous silver nitrate.
What is the formula of the metal bromide?

  A. MBr
  B. MBr$_2$
  C. MBr$_3$
  D. MBr$_4$

(Total 1 mark)

9. An experiment was carried out to determine the relative molecular mass (Mr) of a volatile hydrocarbon X that is a liquid at room temperature.

A known mass of X was vaporised at a known temperature and pressure and the volume of the gas produced was measured in a gas syringe.
Data from this experiment are shown in the table.

Mass of X	194 mg
Temperature	373 K
Pressure	102 kPa
Volume	72 cm^3

(a) Calculate the relative molecular mass of X.
  Show your working.
  Give your answer to the appropriate number of significant figures.
  The gas constant, R = 8.31 J K^{-1} mol^{-1}

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(5)

(b) Analysis of a different hydrocarbon Y shows that it contains 83.7% by mass of carbon.

Calculate the empirical formula of Y.
Use this empirical formula and the relative molecular mass of Y (Mr = 86.0) to calculate the molecular formula of Y.

(4)

10. Ethanedioic acid ($H_2C_2O_4$) is a diprotic acid.

Beekeepers use a solution of this acid as a pesticide. A student carried out a titration with sodium hydroxide solution to determine the mass of the acid in the solution.

The student repeated the titration until concordant titres were obtained.

$H_2C_2O_4(aq) + 2NaOH(aq) \longrightarrow Na_2C_2O_4(aq) + 2H_2O(l)$
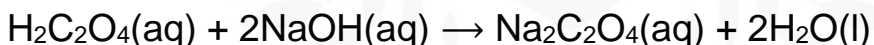
(a) The student found that 25.0 cm³ of the ethanedioic acid solution reacted completely with 25.30 cm³ of 0.500 mol dm⁻³ sodium hydroxide solution.

Calculate the mass, in mg, of the acid in 25.0 cm³ of this solution.
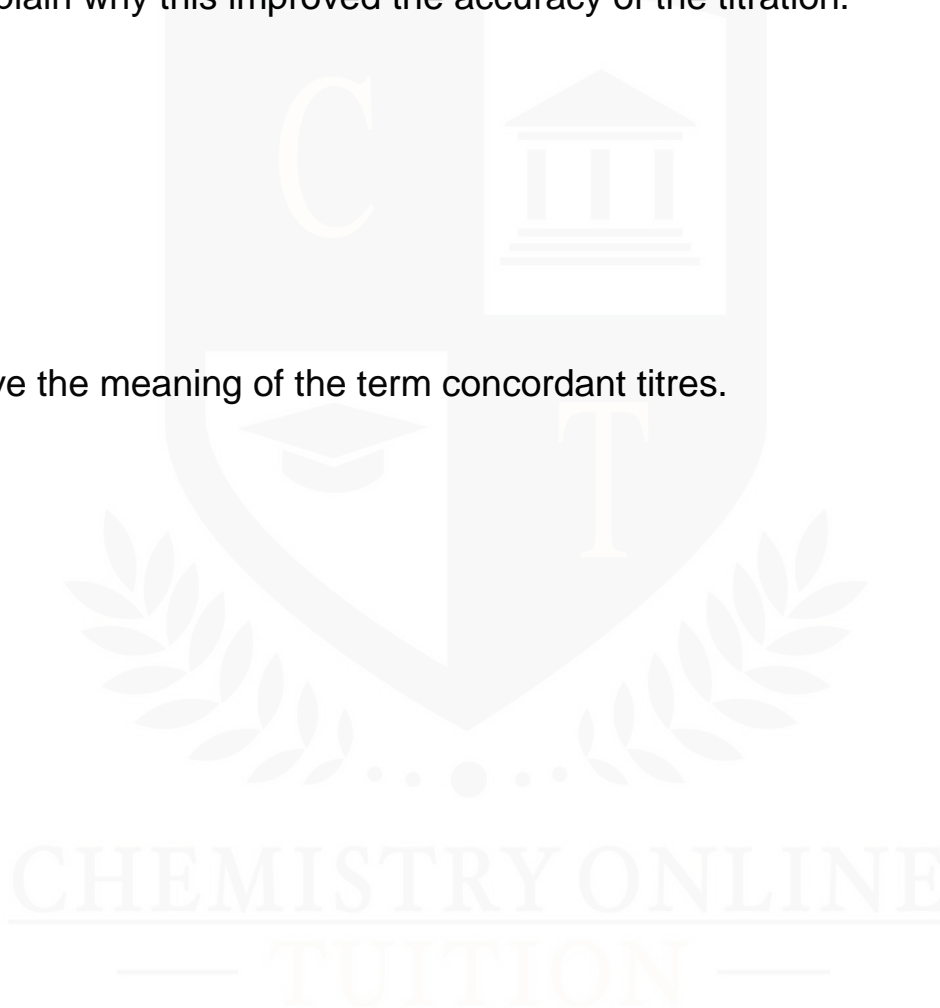
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(4)

(b) The student used a wash bottle containing deionised water when approaching the end-point to rinse the inside of the conical flask. Explain why this improved the accuracy of the titration.

(1)

(c) Give the meaning of the term concordant titres.

(1)

DR. ASHAR RANA

M.B.B.S / MS. CHEMISTRY

Phone: +442081445350
www.chemistryonlinetuition.com
Email: asherrana@chemistryonlinetuition.com

- Founder & CEO of Chemistry Online Tuition Ltd.
- Completed Medicine (M.B.B.S) in 2007
- Tutoring students in UK and worldwide since 2008
- CIE & EDEXCEL Examiner since 2015
- Chemistry, Physics, Math's and Biology Tutor

CONTACT INFORMATION FOR
CHEMISTRY ONLINE TUITION

- UK Contact: 02081445350
- International Phone/WhatsApp: 00442081445350
- Website: www.chemistryonlinetuition.com
- Email: asherrana@chemistryonlinetuition.com

  Address: 210-Old Brompton Road, London SW5 OBS, UK