CHEMISTRY ONLINE TUITION

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CHEMISTRY

PHYSICAL CHEMISTRY

LEVEL & BOARD:	OCR (A - LEVEL)
TOPIC:	AMOUNT OF SUBSTANCE
PAPER TYPE:	QUESTION PAPER 4
TOTAL QUESTIONS	10
TOTAL MARKS	46

Amount of Substance - 4

1. An aqueous solution of iron(III) chloride can be prepared by the redox reaction between iron metal and dilute hydrochloric acid.

(a) A student reacts 0.0600 mol of iron completely with dilute hydrochloric acid to form an aqueous solution of iron(III) chloride. The equation for this reaction is shown below.

$2Fe(s) + 6HCl(aq) \rightarrow 2FeCl_3(aq) + 3H_2(g)$

Calculate the volume of hydrogen gas formed, in dm^3, at room temperature and pressure. [2]

(b) Calculate the mass of $FeCl_3$ formed. Give your answer to three significant figures. [2]

(c) Calculate the volume, in cm^3, of 1.20 mol dm^{-3} hydrochloric acid needed to react completely with 0.0600 mol of iron. [2]

2. Copper reacts with sulfuric acid, $H_2SO_4(aq)$, as shown in the following equation:

$Cu(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2(g)$

A student plans to react 60.0 cm3 of 0.080 mol dm^{-3} H_2SO_4 with 0.150 g of copper (an excess).

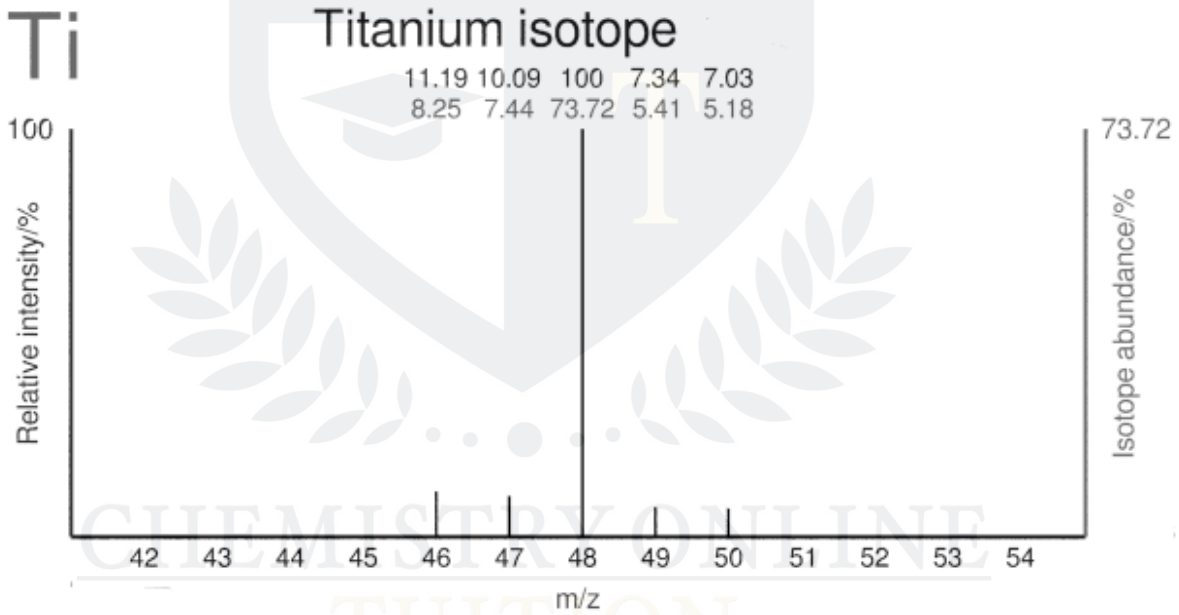
Calculate the volume, in cm^3, of hydrogen that should be produced at RTP. [3]

3. A student reacts 25.0 cm^3 of 4.50×10^{-2} mol dm^{-3} KOH(aq) with an excess of HCl. An equation for this reaction is shown.

$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$

Calculate the mass, in g, of KCl formed in solution. Give your answer to three significant figures. Show your working. [4]

4. In a composite material containing titanium and aluminum, the titanium proportion is examined using mass spectrometry.



(a) Calculate the relative atomic mass of titanium in the composite material, giving your answer to two decimal places. [2]

(b) Given a specific segment of the composite weighing 5.00 g and comprising 84.0% titanium by mass, determine the number of titanium atoms in this segment. Express your answer in standard form and round it to three significant figures. [2]

5. This question explores the properties of alkaline earth metals. Barium and radium are also Group 2 metals. They both react with water. A chemist reacts 0.250 g of radium with 300 cm^3 of water, resulting in a colorless solution containing radium ions. The volume of the solution remains at 300 cm^3.

(a) Write an equation for the reaction between radium and water, including state symbols. [1]

(b) Calculate the concentration, in mol dm^{-3}, of radium ions in the resulting solution. [2]

(c) A student plans to perform this experiment using 0.250 g of barium instead of 0.250 g of radium. Predict the potential difference, if any, in the volume of gas produced by barium compared to radium. Justify your prediction, and include relevant calculations in your explanation. [3]

6. Strontium forms compounds with oxygen, fluorine, and sulfur, resulting in ionic compounds.

(a) Strontium fluoride, SrF_2, possesses a giant ionic lattice structure.

i. Define the term 'ionic bond.' [1]

ii. Construct a 'dot-and-cross' diagram representing the bonding in strontium fluoride, displaying only the outer electrons. [1]

iii. Determine the number of strontium ions in 1.80 g of strontium fluoride. Present your answer in standard form and round to three significant figures. [1]

(b) Strontium sulfate, $SrSO_4$, is soluble in water. Contrast the electrical conductivities of solid and aqueous strontium sulfate. Elaborate on your response concerning the involved particles. [2]

7. Substance X reacts with oxygen to form a compound as the only product.

(a) This reaction is a redox reaction. The molecular formula of the compound formed is the same as its empirical formula.

i. Define what is meant by the term empirical formula. [1]

ii. Propose the empirical formula of the compound formed. [1]

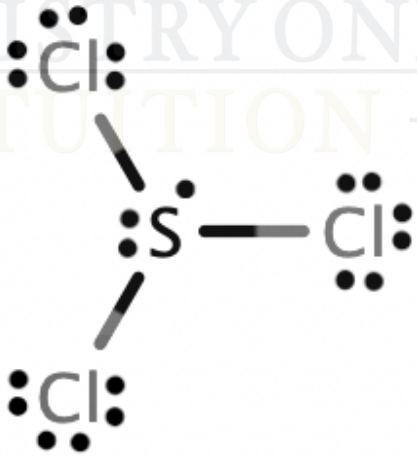
(b) Determine the amount, in mol, of oxygen atoms in 2.450×10^{21} oxygen molecules. [2]

8. Chlorine is a reactive element. It combines with other non-metals to form covalent compounds. Sulfur trichloride, SCl_3, and bromine monochloride, BrCl, are examples of covalent compounds used in organic synthesis. SCl_3 can be prepared by heating chlorine with sulfur, S_8.

(a) Write an equation for this reaction. [1]

(b) How many molecules are present in 1.3535 g of SCl_3? [3]

(c) The 'dot-and-cross' diagram of a molecule of SCl_3 is given below



Name the shape of this molecule and explain why the molecule has this shape. [2]

9. 1-Bromobutane (Mr,136.9) can be made from a reaction of butan-1-ol, C_4H_9OH, as shown in the equation below.

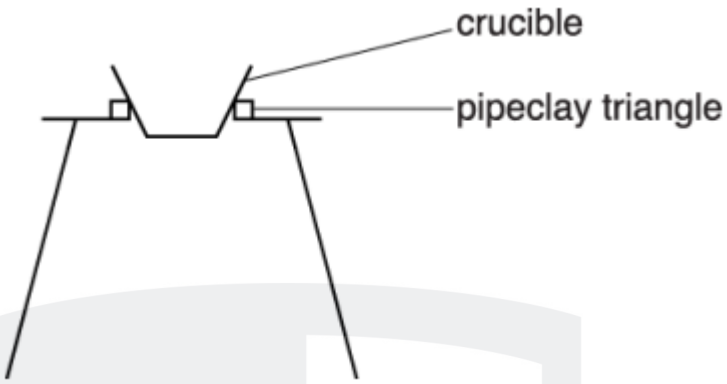
$C_4H_9OH + KBr + H_2SO_4 \rightarrow C_4H_9Br + KHSO_4 + H_2O$

(a) Calculate the atom economy for the formation of 1-bromobutane in this reaction. [1]

(b) Suggest a reactant, other than a different acid, that could be used to improve the atom economy of making 1-bromobutane by the same method. [1]

(c) A student prepares a sample of 1-bromobutane. 5.92 g of butan-1-ol are reacted with an excess of sulfuric acid and potassium bromide. After purification, 9.72 g of 1-bromobutane are collected. Calculate the percentage yield. Give your answer to three significant figures. [3]

10. A student carries out an experiment to determine the amount of water of crystallisation in the formula of hydrated salt. The student intends to remove the water by heating the hydrated salt. A diagram of the apparatus used by the student is shown below.



- The student adds the hydrated salt to the crucible and weighs the crucible and contents.
- The student heats the crucible and contents and allows them to cool.
- The student weighs the crucible and residue.

The student's results are shown below.

Mass of crucible + hydrated salt / g	16.84
Mass of crucible + residue after heating / g	16.26

(a) The maximum error in each mass measurement using the balance is ±0.005 g. Calculate the percentage error in the mass of water removed. [1]

(b) Suggest one modification that the student could make to their method to reduce the percentage error in the mass of water removed. [1]

(c) The student is not sure that all the water of crystallisation has been removed. How could the student modify the experiment to be confident that all the water of crystallisation has been removed? [1]

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