2018 / 2019

1 (a) Bromine has proton number of 35. **FIGURE 1** shows a mass spectrum of bromine.

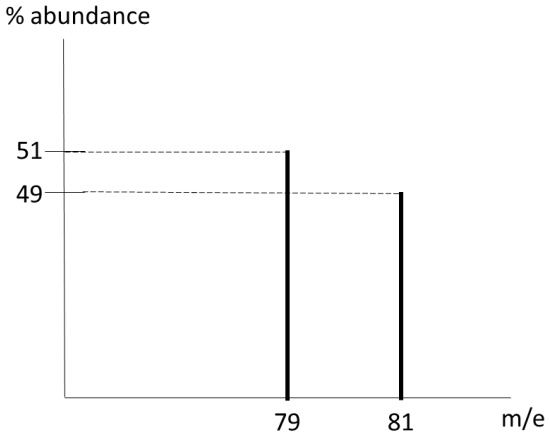


FIGURE 1

(i) Write the notations for all isotopes of bromine.

(ii) Calculate the relative atomic mass of bromine. [4 marks]

(b) A reagent bottle contains a stock solution of 0.90% by mass of sodium chloride, NaCl. The density of the solution is 1.00 g cm^{-3}. Calculate:

(i) The mole fraction of NaCl.

(ii) The molality of NaCl solution.

(iii) The volume of stock solution required to prepare 100 ml 0.01 M NaCl solution. [9 marks]

(c) Silicon tetrachloride, $SiCl_4$ can be prepared by heating silicon in excess chlorine gas.

$$Si\ (s) + 2Cl_2\ (g) \rightarrow SiCl_4\ (l)$$

(i) Calculate the mass of silicon needed to produce 400 g of $SiCl_4$, if the percentage yield is 42.5 %.

(ii) If 15 mol of chlorine is used, determine the amount (mole) of unreacted chlorine. [8 marks]

2019 / 2020

1 (a) Bromine has two stable isotopes, ^{79}Br and ^{81}Br

i) By comparing the number of sub-atomic particles of these isotopes, explain what is meant by the term isotopes.

ii) Determine the number of electrons of Br^- ion [4 marks]

(b) In a complete combustion, 1.00 g sample W ($C_xH_yO_z$) was burnt to produce 2.52 g of carbon dioxide, CO_2 and 0.443 g of water vapour, H_2O. Determine the empirical formula of the compound. [6 marks]

(c) Calcium acetate, $Ca(C_2H_3O_2)_2$ solution is the substance used for reducing phosphate level in late-stage kidney failure. In an experiment, 250 mLof 0.25 M $Ca(C_2H_3O_2)_2$ solution was prepared. Determine the molality of the solution with a density of 1.509 g mL^{-1}. [7 marks]

(d) Magnesium hydroxide, $Mg(OH)_2$ is an antacid that is used to relieve indigestion, sour stomach and heartburn. It can be prepared by reacting magnesium chloride, $MgCl_2$ and sodium hydroxide, NaOH with the by-product of sodium chloride, NaCl. In an experiment, a student allowed 15.1g of $MgCl_2$ to react with 9.35g of NaOH. Calculate the mass (in grams) of $Mg(OH)_2$ that could be obtained at the end of the experiment. [9 marks]

2020/2021

1 (a) Sodium metasilicate, Na_2SiO_3, is used in the production of silica gel

i) Write the isotopic notation for silicon atom
ii) Calculate the number of Si atoms in 50g of Na_2SiO_3 [3 marks]

(b) The following reaction takes place in an acidic condition.

$$MnO_4^- + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+}$$

Write a balance equation for the above reaction [3 marks]

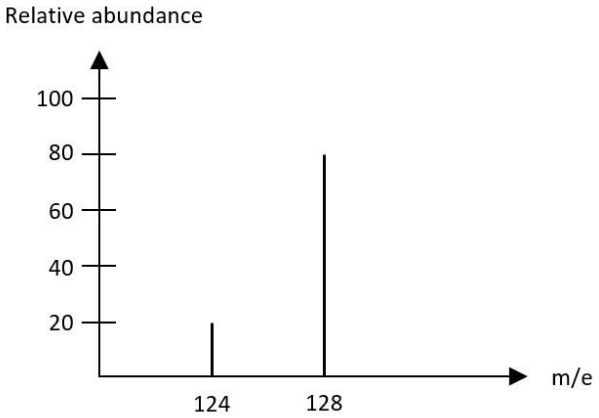
(c) Compound X has a molar mass of 294.20 g. Analysis of X shows that it contains 26.58 g of potassium, 35.35 g of chromium and 38.07 g of oxygen. Determine the molecular formula and name X. [6 marks]

(d) The reaction between nitrogen dioxide, NO_2, with water produces nitric acid, HNO_3, and nitrogen monoxide, NO. In a reaction between 100.0 g of NO_2 and 50.0 g of water, 80.0 g of HNO_3 is produced.

i) Determine the limiting reactant in the reaction.
ii) Determine the percentage yield of the reaction [9 marks]

2021/2022

1 The mass spectrum of an element X is shown below. Calculate the average atomic mass of X?



Magnesium exists naturally as three isotopes. **TABLE 1** shows the percentage abundance of each isotope. Calculate the relative atomic mass of magnesium.

2

TABLE 1

Relative mass of isotope	Percentage abundance of isotope
24	79
25	10
26	11

3 Calculate the mass of perchloric acid, $HClO_4$ needed to prepare 3.45 M perchloric acid solution using 100 mL volumetric flask.

4 Hydrocarbon **E** concists of 82.66% carbon and 17.34% hydrogen with a molar mass of 58 g mol^{-1}. Determine the molecular formula of **E**.

5 Determine the percentage by mass of sugar in pink lemonade if 28.0 sugar is added to 209 g of water.

6 A solution of hydrochloric acid with 37.8% by mass of HCl has a density of 1.19 g cm^{-3}. Calculate the molarity of the concentrated hydrochloric acid.

7 Balance the redox equation in acidic medium based on the given half equations. Determine the stoichiometry coefficient of H_2O.

$$MnO_4^- \rightarrow Mn^{2+}$$
$$C_2O_4^{2-} \rightarrow CO_2$$

8 Hydrogen gas can be produced through the reaction between zinc and hydrochloric acid as follows:

$$Zn\ (s) + 2HCl\ (aq) \rightarrow H_2\ (g) + ZnCl_2\ (aq)$$

If 13.0 g zinc reacts with excess HCl, calculate the volume of hydrogen gas produced at room temperature in unit mL.

2022/2023

1 (a) Magnesium is widely used in constructions and medicines. It occurs in nature as ^{24}Mg, ^{25}Mg and ^{26}Mg. The atomic masses for ^{24}Mg, ^{25}Mg and ^{26}Mg are 23.985 u, 24.986 u and 25.983 u, respectively. Determine the percentage abundance of ^{25}Mg and ^{26}Mg if the percentage abundance of ^{24}Mg is 78.99% and the average atomic mass of magnesium is 24.3. [5 marks]

(b) The equation for the reaction between SO_2 and Br_2 is shown below. Write the balanced equation for this reaction under acidic condition.

$$SO_2 + Br_2 \rightarrow SO_4^{2-} + Br^-$$ [3 marks]

(c) In an experiment, a student was asked to prepare 250 mL of 0.2 M NaOH solution

i) Determine the mass of NaOH required to prepare the solution.

ii) Calculate the volume of water needed to prepare another NaOH solution with a concentration of 0.1 M from the solution prepared in (i). [6 marks]

(d) The reaction equation involved in depletion of ozone, O_3, layer as shown below.

$$O_3\,(g) + NO\,(g) \rightarrow O_2\,(g) + NO_2\,(g)$$

i) An amount 0.740 g of O_3 reacts with 0.670 g of NO. Identify the limiting reactant.

ii) Determine the mass of NO_2 that will be produced. [7 marks]

2023/2024

1 (a) Naturally occurring chlorine has two isotopes. The relative isotopic masses and their abundance are determined using a mass spectrometer. Based on the data in **TABLE 1**, calculate the relative atomic mass of chlorine.

TABLE 1

Isotope	Abundance	Mass
Chlorine-35	75.77 %	34.969 amu
Chlorine-37	24.23 %	36.966 amu

[3 marks]

(b) Barium oxide, BaO reacts with water to produce barium hydroxide, $Ba(OH)_2$ solution. Calculate the mass of BaO needed to prepare 2.50 L of 0.0600 M $Ba(OH)_2$ solution. [3 marks]

(c) An organic compound contains carbon, hydrogen and oxygen. An amount of 141.72 g of this compound is completely burned in excess oxygen to produce 207.8 g of CO_2 and 85.04 g of H_2O. If the molecular weight of this compound is 120 g mol^{-1}, determine the empirical formula and molecular formula. [10 marks]

(d) A solution containing iron (II) ion, Fe^{2+} is titrated with potassium dichromate, $K_2Cr_2O_7$ solution.

(i) Fe^{2+} is oxidised to Fe^{3+} whereas $Cr_2O_7^{2-}$ is reduced to Cr^{3+}.
Write an overall redox equation in an acidic medium.

(ii) When 25.0mL of 0.050 M iron(II) solution is titrated with a 0.0069 M dichromate solution, calculate the volume of dichromate solution needed. [5 marks]

2024/2025

1 (a) **FIGURE 1** shows the mass spectrum of zirconium, Zr which has 40 protons.

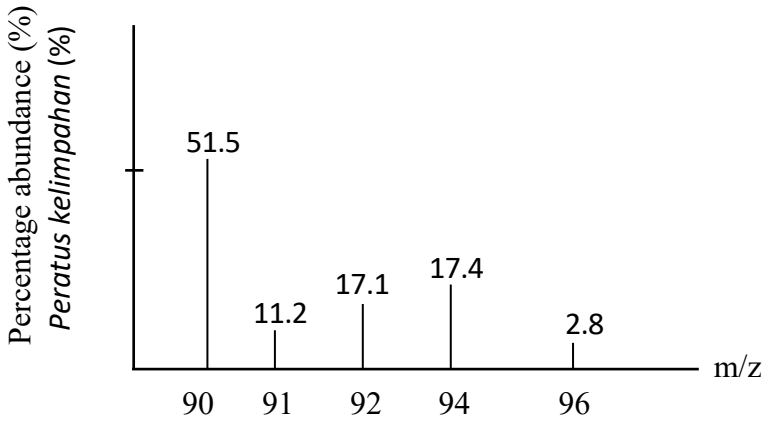


FIGURE 1

(i) Determine the relative atomic mass of zirconium. [4 marks]

(ii) Write the isotopic notation when zirconium atom undergoes ionisation by losing four electrons.

(b) An amount of 12.915 g of an organic compound containing carbon, hydrogen and oxygen was burned in excess oxygen. Analysis of the combustion revealed 18.942 g of carbon dioxide and 7.749 g of water were formed. Determine the empirical formula of the compound. [4 marks]

(c) A reagent bottle contains a concentrated sulphuric acid solution with 98% by mass and a density of 1.83 g mL^{-1}. Calculate the molarity of the acid. [4 marks]

(d) Potassium chlorate reacts with sulphur dioxide in an acidic medium according to the equation below. Balance the reaction equation by using ion-electron method.

$$ClO_3^- + SO_2 \rightarrow SO_4^{2-} + Cl^-$$ [3 marks]

(e) Silicon nitride, Si_3N_4 is a very hard, high-temperature resistant ceramic used as component of turbine blades in jet engines. It is produced according to the equation below:

$$3Si\,(s) + 2N_2\,(g) \rightarrow Si_3N_4\,(s)$$

(i) Calculate the mass of Si_3N_4 produced when 20.00 g of Si and 15.00 g of N_2 are reacted.

(ii) Determine the percentage yield if 24.75g of Si_3N_4 is obtained in this reaction. [6 marks]