

S5 TOPICAL BREEZER 2023

TOPIC: PARTICULATE NATURE OF MATTER

DATE: 9<sup>th</sup> MARCH 2023

20  
32

NAME ..... COMBN .....

INSTRUCTION: Attempt all questions

1. (a) Describe how in a mass spectrometer the ions are:

(i) formed

When a beam of fast moving electrons <sup>emitted</sup> by electron gun bombard with molecules of the injected vapourised sample. 01/2

(ii) accelerated

They are accelerated by a strong electric field of varying potentials and <sup>ions</sup> move with same velocity. 01/2

(iii) separated

By circular electromagnetic fields produced by electromagnet and are deflected according to their mass to charge ratio. 01/2

(iv) detected

<sup>on the ion collector</sup> The ions are changed into sizeable electric current that is sent to the amplifier connected to a recorder that generate peaks of variable relative intensities. 01/2

b) State two advantages and one disadvantage of using mass spectrometer

Advantages

- Requires <sup>(a)</sup> small sample <sup>any 2</sup>
- It is quicker
- More accurate
- Gives information about the different isotopes of an element.
- Gives information of what functional groups are present in organic compound.

Disadvantage

- Expensive <sup>(or)</sup>
- Only uses samples in <sup>(any one)</sup> vapour form.

c) State one use of a mass spectrometer to a chemist.

- To determine the Relative Atomic mass <sup>(or)</sup> of an element
- Gives information about the different isotopes of that element

2. (a) Bromine has two isotopes Br-79 and Br-81 and the mass spectrum of bromine shows peaks at  $m/e$  of 158, 160 and 162.

(a) Write the formula(e) of the ion(s) corresponding to the peak(s)

Peak value	Formula of ion
158	$[^{79}\text{Br}-^{79}\text{Br}]^+$ ✓
160	$[^{79}\text{Br}-^{81}\text{Br}]^+$ ✓
162	$[^{81}\text{Br}-^{81}\text{Br}]^+$ ✓

or 1/2

- (ii) Use the information in the table to calculate an accurate value for the relative atomic mass of magnesium.

$$R.A.M = \frac{\sum \text{Isotopic mass} \times \text{Relative abundance}}{\text{Total Relative abundance}}$$

$$= \frac{(24 \times 1) + (25 \times 0.127) + (26 \times 0.139)}{1 + 0.127 + 0.139}$$

$$= 24.789$$

Accept;

$$\text{Total Rel. abundance} = 1 + 0.127 + 0.139 = 1.266$$

$$\% \text{ abundance for Mg-24} = \frac{1}{1.266} \times 100 = 78.98\%$$

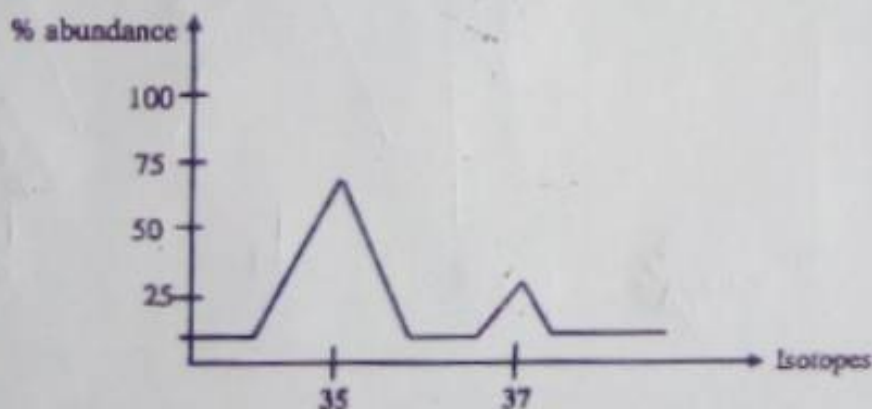
$$\% \text{ abundance for Mg-25} = \frac{0.127}{1.266} \times 100 = 10.05\%$$

$$\% \text{ abundance for Mg-26} = \frac{0.139}{1.266} \times 100 = 10.99\%$$

Alternatively:

$$RAM = \frac{(78.98 \times 24) + (10.05 \times 25) + (10.99 \times 26)}{100} = 24.789$$

4. The figure below shows a mass spectrum for chlorine.



Determine the relative atomic mass of chlorine

$$R.A.M = \frac{\sum \text{Isotopic mass} \times \text{Relative abundance}}{\text{Total Relative abundance}}$$

$$= \frac{(75 \times 35) + (25 \times 37)}{100}$$

$$R.A.M = 35.5$$



(b) By calculation, deduce which of the isotopes in (b) above is most abundant if the relative atomic mass of bromine is 79.9.

Let the Relative abundance of Br-79 be  $x$   
Relative abundance of Br-81 be  $100-x$

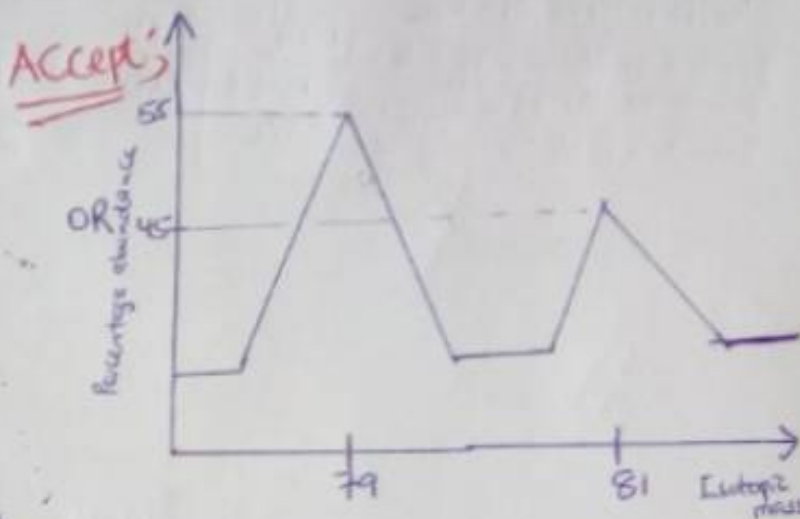
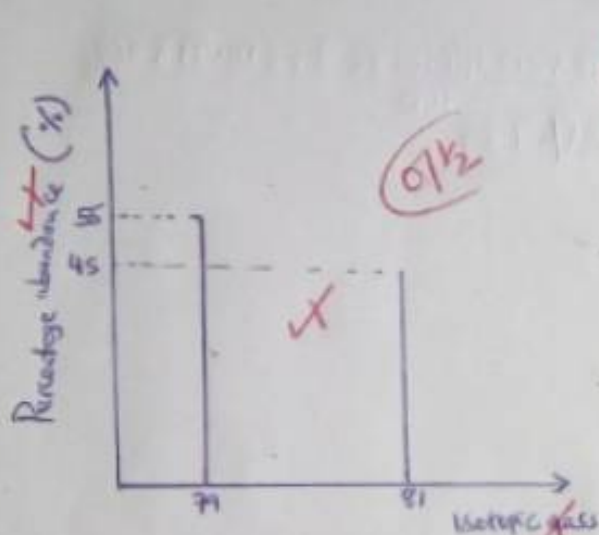
From  $R.A.M = \frac{\sum \text{isotopic mass} \times \text{Relative abundance}}{\text{Total Relative abundance}} = 79.9$

$$79.9 = \frac{(79 \times x) + 81(100-x)}{100}$$

$$x = 55$$

Relative abundance for Br-79 is 55%, and that of Br-81 is 45%.  $\therefore$  Most abundant isotope is Br-79

(c) Sketch a mass spectrum for bromine using the above information.



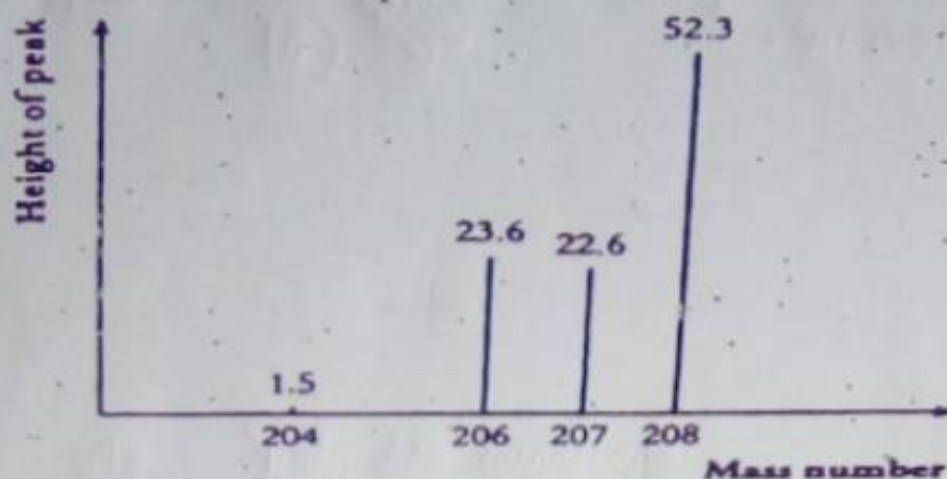
3. The mass spectrum of a sample of magnesium contains three peaks with mass-charge ratios and relative intensities show below.

$m/z$	24	25	26
Relative intensity	1	0.127	0.139

(i) Explain why magnesium gives three peaks in its spectrum.

Because it has three isotopes of different relative intensities.

5. The figure below shows the mass spectrum of lead. The heights of the peaks and the mass numbers of the isotopes are shown on the figure.



- (a) Calculate the relative atomic mass of lead.

$$\begin{aligned}
 \text{RAM} &= \frac{\sum \text{isotopic mass} \times \text{Relative abundance}}{\text{Total Relative abundance}} \\
 &= \frac{(204 \times 1.5) + (206 \times 23.6) + (207 \times 22.6) + (208 \times 52.3)}{1.5 + 23.6 + 22.6 + 52.3} \\
 &= 207.24
 \end{aligned}$$

- (b) Explain why the peaks have different heights.

Lead has four isotopes of different relative intensities.



6. (a) State Graham's law of gaseous diffusion.

(1 mark)

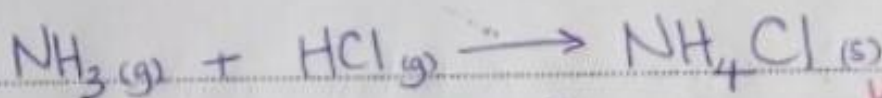
The rate of diffusion of a gas is inversely proportion to the square root of its density at constant temperature and pressure.

(b) Two pieces of cotton wool were each soaked separately in concentrated ammonia solution and concentrated hydrochloric acid respectively and simultaneously inserted into opposite ends of a horizontal wide glass tube. After a short time a white ring was across the tube. If the distance between the inner surfaces of the cotton wool plugs is 50cm.

(i) Name the white ring

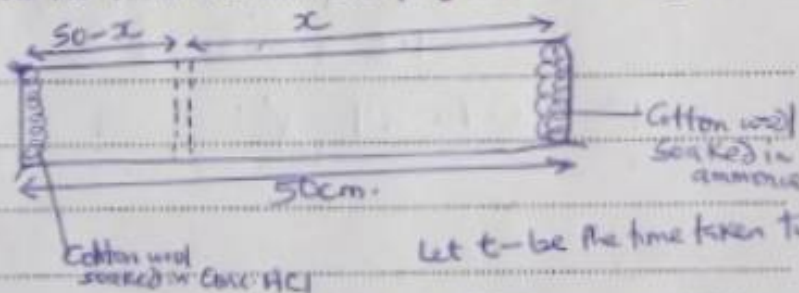
Ammonium chloride

(iii) Write the equation leading to formation of the white ring.



Accept:

(iii) Determine how far from the ammonia plug the white ring is formed.



Let t be the time taken to form white fume

Rate of diffusion of  $\text{NH}_3 = \frac{x}{t}$  , Rate of diffusion of  $\text{HCl} = \frac{50-x}{t}$

From Graham's law,

$$\frac{\text{Rate of diffusion of } \text{NH}_3}{\text{Rate of diffusion of } \text{HCl}} = \sqrt{\frac{M_{\text{rHCl}}}{M_{\text{rNH}_3}}}$$

$$\frac{\frac{x}{t}}{\frac{50-x}{t}} = \sqrt{\frac{36.5}{17}}$$

$\therefore$  A distance of 29.72cm to the point of formation of white ring

7. (a) A gas Q diffuses 4 times as rapidly as sulphur dioxide under the same conditions. If the density of sulphur dioxide under the same conditions of temperature and pressure is, calculate the density of Q

Rate of diffusion of Q =  $4x$ , Rate of diffusion of  $\text{SO}_2 = x$   
Molar mass of  $\text{SO}_2 = 32 + (16 \times 2) = 64\text{g}$

$$\frac{\text{Rate of diffusion of Q}}{\text{Rate of diffusion of SO}_2} = \sqrt{\frac{M_{\text{SO}_2}}{M_{\text{Q}}}}$$

Since  $M \propto \text{Density}$

$$\frac{4x}{x} = \sqrt{\frac{64}{M_{\text{Q}}}}$$

$$M_{\text{Q}} = 4$$

$$\therefore \text{Density} = 4 \text{ g cm}^{-3}$$

- (b)  $250 \text{ cm}^3$  of an alkene diffuse through a porous medium in 10 seconds and  $716 \text{ cm}^3$  of oxygen diffuse through the same medium in 25 seconds under the same conditions. Calculate the molecular mass of the alkene and deduce its structural formula.

Rate of diffusion of alkene =  $\frac{250}{10} \text{ cm}^3 \text{ s}^{-1}$ , Rate of diffusion of  $\text{O}_2 = \frac{716}{25} \text{ cm}^3 \text{ s}^{-1}$

From Graham's Law,

$$\frac{\text{Rate of diffusion of alkene}}{\text{Rate of diffusion of O}_2} = \sqrt{\frac{M_{\text{O}_2}}{M_{\text{alkene}}}}$$

$$\frac{250}{10} \div \frac{716}{25} = \sqrt{\frac{32}{M_{\text{alkene}}}}$$

$$(0.8729)^2 = \frac{32}{M_{\text{alkene}}}$$

$$M_{\text{alkene}} = 41.9968$$

WELCOME TO CHEMISTRY CLASS 2023.

$$\text{C}_n\text{H}_{2n} = 41.9968$$

$$12n + 2n = 41.9968$$

$$n = 3$$

Page 7 of 7

$\therefore$  Molecular formula is  $\text{C}_3\text{H}_6$

Structural formula is  $\text{CH}_3\text{CH}=\text{CH}_2$