



# TIME OF FLIGHT MASS SPECTROMETRY 3

Avogadro constant  $L = 6.022 \times 10^{23} \text{ mol}^{-1}$

Kinetic energy =  $\frac{mv^2}{2}$

- 1 It takes the  $^{12}_6\text{C}^+$  ion  $1.23 \times 10^{-5} \text{ s}$  to travel along the flight tube in a time of flight mass spectrometer having been given  $5.94 \times 10^{-17} \text{ J}$  of kinetic energy. Calculate the length of the flight tube.

$$KE = \frac{mv^2}{2} = \frac{md^2}{2t^2}$$

$$d^2 = \frac{2 KE t^2}{m}$$

$$d = \sqrt{\frac{2 KE t^2}{m}} = \sqrt{\frac{2 (5.94 \times 10^{-17}) (1.23 \times 10^{-5})^2}{\frac{0.012}{6.022 \times 10^{23}}}} = 0.95 \text{ m (2sf)}$$

- 2 Find the time it takes the  $^7_3\text{Li}^+$  ion to travel down a 78 cm time of flight tube given  $1.52 \times 10^{-18} \text{ J}$  of kinetic energy.

$$KE = \frac{mv^2}{2} = \frac{md^2}{2t^2}$$

$$t^2 = \frac{m d^2}{2 KE}$$

$$t = \sqrt{\frac{m d^2}{2 KE}} = \sqrt{\frac{\frac{0.007}{6.022 \times 10^{23}} (0.78)^2}{2 (1.52 \times 10^{-18})}} = 4.8 \times 10^{-5} \text{ s (2sf)}$$

- 3 It takes the  $^{81}_{35}\text{Br}^+$  ion  $2.83 \times 10^{-5} \text{ s}$  to travel along the flight tube in a time of flight mass spectrometer. How long would it take the  $^{79}_{35}\text{Br}^+$  ion to travel down the same flight tube under the same conditions?

$$KE = \frac{mv^2}{2} = \frac{md^2}{2t^2}$$

$$\text{isotope 81 } \frac{md^2}{2t^2} = \text{isotope 79 } \frac{md^2}{2t^2}$$

$$\frac{\text{mass}(81) \times d^2}{2 \text{time}(81)^2} = \frac{\text{mass}(79) \times d^2}{2 \text{time}(79)^2}$$

we can cancel out the  $d^2$  and the 2

$$\frac{\text{mass}(81)}{\text{time}(81)^2} = \frac{\text{mass}(79)}{\text{time}(79)^2}$$

$$\text{time}(79)^2 = \frac{\text{mass}(79) \times \text{time}(81)^2}{\text{mass}(81)}$$

$$\text{time}(79) = \text{time}(81) \sqrt{\frac{\text{mass}(79)}{\text{mass}(81)}} = 2.83 \times 10^{-5} \times \sqrt{\frac{79}{81}} = 2.79 \times 10^{-5} \text{ s}$$

- 4 An ion takes  $3.81 \times 10^{-5}$  s to travel along the 85 cm flight tube in a time of flight mass spectrometer having been given  $1.6 \times 10^{-17}$  J of kinetic energy. Calculate the mass number of this ion.

$$KE = \frac{mv^2}{2} = \frac{md^2}{2t^2}$$

$$m = \frac{2 KE t^2}{d^2}$$

$$m = \frac{2 (1.6 \times 10^{-17}) (3.81 \times 10^{-5})^2}{0.85^2} = 6.48 \times 10^{-26} \text{ kg}$$

$$\text{mass of 1 mole} = 6.48 \times 10^{-26} \times 6.022 \times 10^{23} = 0.039 \text{ kg}$$

$$\text{mass number} = 39$$

- 5 The relative atomic mass of lithium is 6.924. It consists of two isotopes,  ${}^6_3\text{Li}$  and  ${}^7_3\text{Li}$ . Find the percentage composition by mass of  ${}^6_3\text{Li}$  in lithium.

$$\text{let \% of } {}^6_3\text{Li} = a$$

$$6.924 = \frac{6a + 7(100 - a)}{100}$$

$$692.4 = 6a + 7(100 - a)$$

$$692.4 = 6a + 700 - 7a$$

$$a = 7.6$$

- 6 The relative atomic mass of silicon is 28.109. It consists of three isotopes,  ${}^{28}_{14}\text{Si}$ ,  ${}^{29}_{14}\text{Si}$  and  ${}^{30}_{14}\text{Si}$ . It contains 92.2%  ${}^{28}_{14}\text{Si}$ . Find the percentage composition by mass of  ${}^{29}_{14}\text{Si}$  in silicon.

$$\text{let \% of } {}^{29}_{14}\text{Si} = b$$

$$\text{therefore \% of } {}^{30}_{14}\text{Si} = (100 - 92.2) - b = 7.8 - b$$

$$28.109 = \frac{28(92.2) + 29b + 30(7.8 - b)}{100}$$

$$2810.9 = 2581.6 + 29b + 234 - 30b$$

$$b = 4.7$$