If 465 cm^3 of sulphur(IV) oxide, can diffuse through porous partition in 30 seconds, how long will (a) an equal volume, (b) 620 cm^3 of hydrogen sulphide take to diffuse through the same partition

Solution

To answer this question we should use Graham's Law: rate of effusion for a gas is inversely proportional to the square root of it's molar mass:

Rate of effusion = $1/\sqrt{M}$.

For two gases:

Rate A/Rate B = $\sqrt{M_B}/M_A$.

a) We have: $V(SO_2)= 0.465\ dm^3$
$t\ (SO_2) = 30\ s$
$V(H_2S)= 0.465\ dm^3$

Rate $SO_2 = n\ (SO_2)/t$;
$n(SO_2)= V/V_m$; $V_m = 22.4\ dm^3/mol$;
$n(SO_2) = 0.465\ dm^3/22.4\ dm^3/mol = 0.021\ mol$;
rate $SO_2 = 0.021\ mol/30\ s = 6.92 \cdot 10^{-4}\ mol/s$.

Find rate H_2S from Graham's Law:
$6.92 \cdot 10^{-4}/\text{rate } H_2S = \sqrt{34.09/64.07}$,
where $M(H_2S)=1.01 \cdot 2+32.07=34.09\ (g/mol)$, $M(SO_2) = 32.07+16.00 \cdot 2 = 64.07\ (g/mol)$;
rate $H_2S = 9.49 \cdot 10^{-4}\ mol/s$.

Find chemical amount of H_2S:
$n(H_2S)= V/V_m$; $V_m = 22.4\ dm^3/mol$;
$n(H_2S) = 0.465\ dm^3/22.4\ dm^3/mol = 0.021\ mol$.

Rate $H_2S = n(H_2S)/t$;
$9.49 \cdot 10^{-4}\ mol/s = 0.021\ mol/t$;
$t = 21.87\ s$.

b) We have: $V(SO_2)= 0.465\ dm^3$
$t(SO_2)= 30s$
$V(H_2S) = 0.620\ dm^3$

Rate $SO_2 = n\ (SO_2)/t$;
$n(SO_2)= V/V_m$; $V_m = 22.4\ dm^3/mol$;
$n(SO_2) = 0.465\ dm^3/22.4\ dm^3/mol = 0.021\ mol$;
rate $SO_2 = 0.021 mol/30\ s = 6.92 \cdot 10^{-4}\ mol/s$.

Find rate H_2S from Graham's Law:
$6.92 \cdot 10^{-4}/\text{rate } H_2S = \sqrt{34.09/64.07}$,
where $M(H_2S)=1.01 \cdot 2+32.07=34.09\ (g/mol)$, $M(SO_2) = 32.07+16.00 \cdot 2 = 64.07\ (g/mol)$;
rate $H_2S = 9.49 \cdot 10^{-4}\ mol/s$.

Find chemical amount of H_2S:
$n(H_2S) = V/V_m$; $V_m = 22.4\ dm^3/mol$;
$n(H_2S) = 0.620\ dm^3/22.4\ dm^3/mol = 0.0277\ mol$.

Rate $H_2S = n(H_2S)/t$;
$9.49 \cdot 10^{-4}\ mol/s = 0.0277\ mol/t$;
$t = 29.19\ s$.

Answer: a) 21.87 s; b) 29.19 s