25.1 Test the 3 possible shrinking-core mechanisms to see which is consistent with the following reported data

$$\left.\begin{array}{ll} X_B = 0.875 & \text{at } t = 1\,\text{hr} \\ X_B = 1.000 & \text{at } t (= \tau) = 2\,\text{hr} \end{array}\right\} \cdots \text{or } X_B = 7/8 \text{ at } \frac{t}{\tau} = 0.5$$

Since the shape of the solids is not specified assume to start with that they are spherical. Then from Table 1

If film diffusion controls: $\frac{t}{\tau} = X_B$

but from the data: $0.5 \stackrel{?}{=} 0.875$ ... this doesn't agree, so we reject this mechanism

If ash diffusion controls: $\frac{t}{\tau} = 1 - 3(1-X_B)^{2/3} + 2(1-X_B)$

again from the data $0.5 \stackrel{?}{=} 1 - 3(1/8)^{2/3} + 2(1/8) = 0.5$ ... this agrees

Now before we feel that all is solved let us try the third mechanism. Who knows, maybe it too will fit. So

If surface reaction controls: $\frac{t}{\tau} = 1 - (1-X_B)^{1/3}$

& again from the data: $0.5 \stackrel{?}{=} 1 - (1/8)^{1/3}$ ... amazing, this also fits!

So here we have a coincidence where both reaction & ash diffusion mechanisms fit the data

Note - Figure 9 or 10 shows that the data were taken at the precise point where the ash diffusion curve crosses the reaction controlling curve.

- If we try the equations for flat plate or cylindrical pellets we find that neither will fit the data.

25·3 Here we have shrinking particles, hence only 2 possible resistances, film diffusion & surface reaction. Since we are told that we can ignore film diffusion we are left with reaction controlling alone. So solve for this case.

From Table 1 pg 580 we have for reaction controlling

$$\frac{t}{\tau} = 1-(1-X_B)^{1/3} \quad \cdots \text{ where } \tau = \frac{\rho_B R_o}{b\, k_s C_{Ag}}$$

but $\rho_B = \dfrac{2.2\ gm/cm^3}{12\ gm/mol} = 0.183\ mol/cm^3$

$$C_{Ag} = \frac{1\ mol}{22400\ cm^3} \cdot \frac{273}{273+900} \cdot 0.08 = 8.30 \times 10^{-7}\ mol/cm^3$$

for the reaction $C + O_2 \rightarrow CO_2$ ··· $b = 1$

Replacing these quantities in the τ expression gives

$$\tau = \frac{(0.183)(0.5)}{(1)(20)(8.3\times10^{-7})} = 5510\ sec = 1.53\ hr \longleftarrow$$

25·5 Let 1 refer to particles of size R
2 " " " " " $2R$ } then $\tau_2 = 3\tau_1$ ····(0)

Now $\tau_1 = \tau_{1ash} + \tau_{1rxn}$ ·····(i)

$\tau_2 = \tau_{2ash} + \tau_{2rxn}$ ·····(ii)

But $\tau_{2ash} = 4\tau_{1ash}$ ········(iii)

$\tau_{2rxn} = 2\tau_{1rxn}$ ·······(iv)

So (iii) & (iv) & (0) in (ii) gives $3\tau_1 = 4\tau_{1ash} + 2\tau_{1rxn}$ ·····(v)

From (i) and (v) we find $\tau_{1ash} = \tau_{1rxn}$

∴ the % contribution of ash diffusion for R = 50% ⟵

25.7

d_t	X_B	t	$\frac{R^2}{t}\left[1-3(1-X_B)^{2/3}+2(1-X_B)\right]$ guess ash diffusion controls	$\frac{R}{t}\left[1-(1-X_B)^{1/3}\right]$ guess reaction controls
1	1	4	0.0625	0.125
1.5	1	6	0.0938	0.125

same value

∴ chemical reaction controls

25.9

d_t	X_B	t	$\frac{R^2}{t}\left[1-3(1-X_B)^{2/3}+2(1-X_B)\right]$ ash	$\frac{R}{t}\left[1-(1-X_B)^{1/3}\right]$ reaction controls
1	1	200	1.25×10^{-3}	2.5×10^{-3}
1.5	1	450	1.25×10^{-3}	1.67×10^{-3}

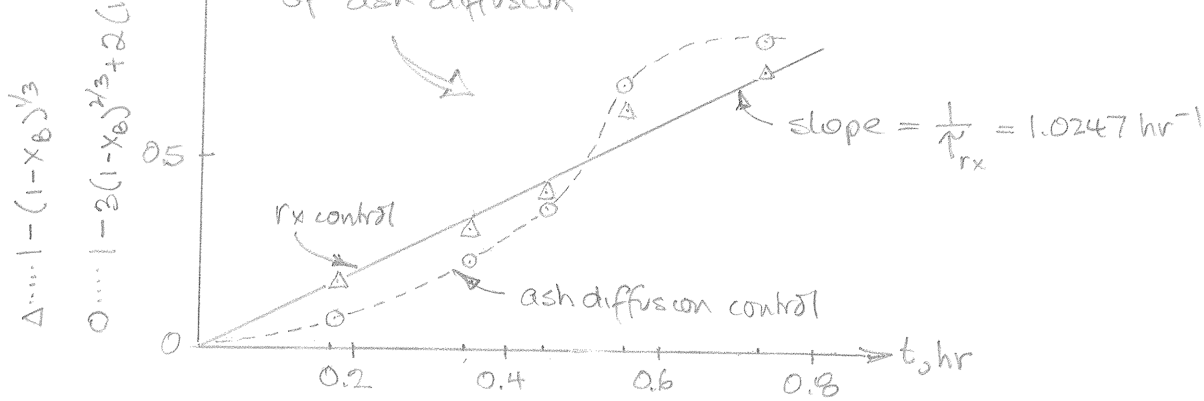
same

∴ ash diffusion controls

25.11 Plot assuming that reaction, and then ash diffusion controls

t, hr	0.180	0.347	0.453	0.567	0.733
X_B	0.45	0.68	0.80	0.95	0.98
$1-(1-X_B)^{1/3}$	0.1807	0.3160	0.4152	0.6316	0.7286
$1-3(1-X_B)^{2/3}+2(1-X_B)$	0.0861	0.2365	0.3740	0.6928	0.8190

The assumption of reaction control gives a better straight line fit than does the assumption of ash diffusion



From the above plot $\frac{t}{\tau_{rx}} = 1-(1-X_B)^{1/3}$

$\tau_{rx} = \tau = 0.98$ hr