Graphs III

Obtaining linear graphs from non-linear functions

29

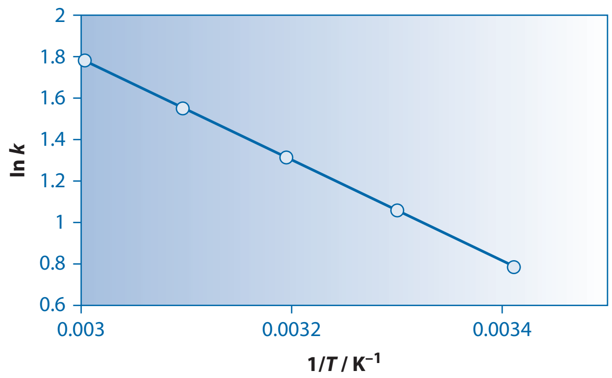
Answers to additional problems

29.1 We first split the equation,

Equation of a straight line	y	=	m	x	+	c
Linearized line	$\ln k$	=	$-\frac{E_a}{R}$ ×	$\frac{1}{T}$	+	c

so a plot of ln k (as y) against $1/T$ (as x) should be linear with a gradient of $-E_a/R$ and an intercept on the y-axis of c.

29.2 To show these data follow the Arrhenius equation, we plot a graph of ln k (as y) against $1/T$ (as x). The graph is indeed linear so the data fit the Arrhenius equation.



The intercept is 9.01. The gradient is –2408. E_a is ($-R \times -2408$) so E_a = 20 kJ mol^{-1}.

- The graph will be curved rather than linear if we do not convert from °C to Kelvin.

29.3 We first split the equation,

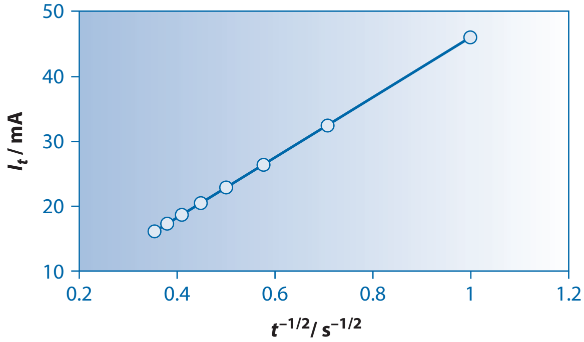
Equation of a straight line	y	=	m	×	x	+	c
Linearized equation	I_t	=	$nFAc\sqrt{\frac{D}{\pi}}$	×	$\sqrt{\frac{1}{t}}$		

A graph of I_t as (y) against $t^{-1/2}$ (as x) will be linear and its gradient is $nFAc\sqrt{\frac{D}{\pi}}$. There is no constant term (so the intercept c = 0).

A linearized graph should pass through the origin with no intercept.

- We must ensure the solution is not stirred so 'still' (or 'quiescent').

29.4 We draw a Cottrell plot of I_t (as y) against $t^{-½}$ (as x). The graph is linear so the data fit the Cottrell equation. $I_t = 4.59 \times 10^{-5}\ t^{-½}$.

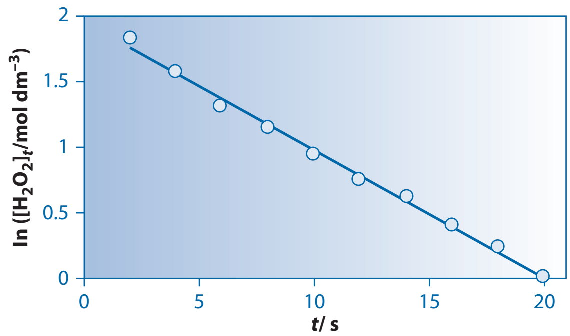


29.5 We first split the equation,

Equation of a straight line	y	$=$	mx	$+$	c
Linearized equation	$\ln\,[\mathrm{A}]_t$	$=$	$-k\,t$	$+$	c

Data that follow first-order kinetics will generate a linear graph when we plot ln $[\mathrm{A}]_t$ (as y) against t (as x). The gradient will be $-k$ and the intercept on the y-axis will be c.

29.6 We plot ln $[H_2O_2]_t$ (as y) against t (as x). The graph is linear, so the data do indeed follow a first-order rate law.
The intercept is 1.96. The gradient is –0.097 6 so $k = 9.76 \times 10^{-2}\ \mathrm{s}^{-1}$.

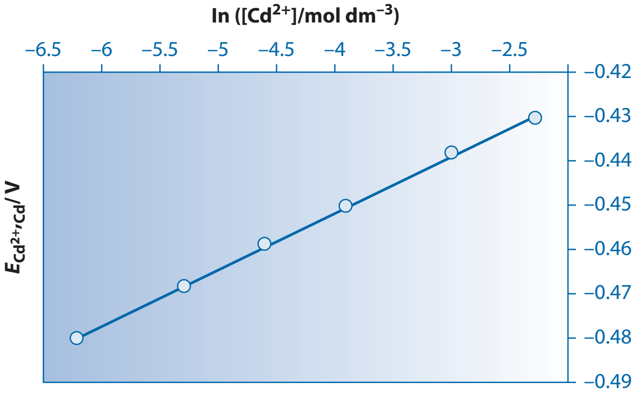


29.7 We first linearize the equation,

Equation of a straight line	y	$=$	c	$+\ m$	x
Linearized equation	$E_{\mathrm{Cd^{2+},Cd}}$	$=$	$E^{\ominus}_{\mathrm{Cd^{2+},Cd}}$	$+\ \frac{RT}{2F}$	$\ln[\mathrm{Cd^{2+}}]$

A plot of $E_{\mathrm{Cd^{2+},Cd}}$ (as y) against ln $[\mathrm{Cd^{2+}}]$ (as x) should be linear with a gradient of $RT/2F$ and an intercept on the y-axis of $E^{\ominus}_{\mathrm{Cd^{2+},Cd}}$.

29.8 To show these data follow the Nernst equation, we plot a graph of $E_{Cd^{2+},Cd}$ (as y) against ln $[Cd^{2+}]$ (as x). The graph is indeed linear, so the data fit the Nernst equation.



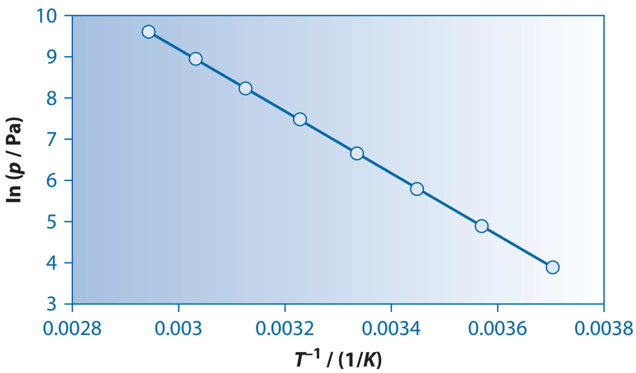
The intercept = –0.400 so $E^{\ominus}_{Cd^{2+},Cd}$ = –0.400 V and the gradient is $RT/2F$ = 0.0129 V.

- The correct intercept occurs when the line crosses the ordinate at $x = 0$ (see Chapter 28).

29.9

Equation of a straight line	y	=	m	x	+	c
Linearized equation	$\ln p$	=	$-\frac{\Delta H^{\ominus}_{vap}}{R}$	$\times \frac{1}{T}$	+	c

so a plot of $\ln p$ (as y) against $1/T$ (as x) should be linear with a gradient of $-\Delta H^{\ominus}_{vap}/R$ and an intercept on the y-axis of c. The graph is indeed linear so the data fit the Clausius–Clapeyron equation.
The intercept = 31.5 and the gradient = –7 454 so $\Delta H^{\ominus}_{vap}$ = 62.0 kJ mol^{-1}.



29.10 We first split the equation,

Equation of a straight line	y	=	mx	+	c
Linearized equation	$1/[NO]_t^2$	=	$2kt$	+	c

so a plot of $1/[NO]_t^2$ (as y) against t (as x) should be linear with a gradient of $2 \times k$, and an intercept on the y-axis of c.