# Example: Half-Life of $N_2O_5$

Q: $N_2O_5$ dissolved in $CCl_4$ decomposes to give $N_2O_4$ and $O_2$. The reaction is first order with a half-life of 1234 seconds. How long will it take, in seconds, for the concentration of $N_2O_5$ to fall to 1.1% of its initial value?

A: Recall the half-life formula for first order reactions,

$$t_{1/2} = \frac{\ln(2)}{k},$$

and the formula for the integrated rate law,

$$\log\left(\frac{C_F}{C_i}\right) = -kt.$$

Then, solve for $k$ in the integrated rate law,

$$k = -\log\left(\frac{C_F}{C_i}\right)/t$$

Plug in the given half life and concentrations,

$$1234 = \frac{\ln(2)\, t}{-\log(0.011)} \Rightarrow \boxed{t = 3486.88 \text{ seconds}}$$

# Example: Two Kinetics Questions

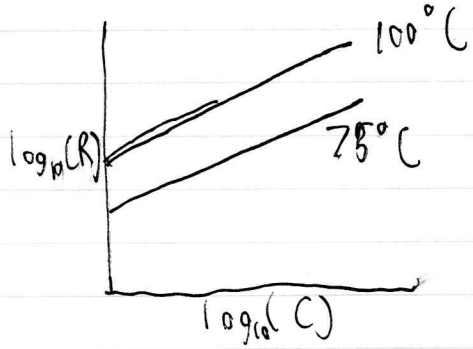
Q: Urbium (Ur) is an unscale element found in big cities. Its oxide, ~~$UrO_3$~~ $UrO_2$, is not very stable at high temperatures, exceeding 66°C. The figure below shows how the rate of reaction varies with the concentration of $UrO_2$ at 75°C:


Where Rate = R & [R] = $M\ s^{-1}$, and Concentration = C & [C] = mole $L^{-1}$. The line has slope 1.34 and intercept 1.51. What is the order for the decomposition of urbium oxide?

A: 1.34.

Q: Sketch the graph that best represents how the rate of reaction varies with concentration at 100°C vs 75°C:

A:



## Example: Band-gap of InP and InN

Q: Which material would you expect to have a greater bandgap energy: InN, or InP?

A: InN has a higher bonding energy and thus larger band gap.

# Example: Absorption Edge of GaN

(Q): Gallium nitride is a semi-conductor with a bandgap $E_g = 3.2\,eV$. Calculate the absorption edge in units of meters.

(A): Recall the formula

$$\lambda_c = \frac{hc}{E_g}$$

Note that $3.2\,eV = 1.527 \cdot 10^{-19}\,J$, then

$$\lambda_c = \frac{(6.626 \cdot 10^{-34})(3 \cdot 10^8)}{1.527 \cdot 10^{-19}} = 3.875 \cdot 10^{-7}\,m$$

## Example: Band-gap of InAs

(Q): Is the band gap of Indium arsenide greater or smaller than the band gap of Gallium arsenide? (GaAs) Why? (InAs)

| | |
|---|---|
| | Greater : Atomic Radius of In > Ga |
| | Greater : The InAs bond is stronger than the GaAs bond. |
| X | Smaller : The InAs bond is weaker " |
| | Same : The As-As bond is the same in both cases |

# Example: Band-gap of InGaAs

(Q): The band-gap of InGaAs varies based on the concentration of gallium in the material. A sample of InGaAs absorbs light with a wavelength less than 1.37 microns. What is the Band gap of the InGaAs sample in eV?

(A): Convert 1.37 microns $= 1.37 \cdot 10^{-6}$ m, then

$$E_g = \frac{hc}{\lambda_c} \Rightarrow E_g = \frac{(6.626 \cdot 10^{-34})(3 \cdot 10^{8})}{1.37 \cdot 10^{-6}} = 1.45 \cdot 10^{-19} \text{ J} = 0.905 \text{ eV}$$

## Example: Band gap emission from Silicon

(Q): An electron falls from the conduction band of Silicon (Si) to the valence band. The band gap of Si is 1.1 eV. What is the wavelength of the photon emitted by this process? Give your answer in nm.

(A): We see that $1.1\,eV \simeq 1.762 \cdot 10^{-19}\,J$; recall

$$E \simeq \frac{hc}{\lambda} \Rightarrow \lambda \simeq \frac{hc}{E} = \frac{(6.626 \cdot 10^{-34})(3 \cdot 10^{8})}{1.762e\text{-}19} \simeq 1127.381\,nm$$