AP CHEMISTRY • EXERCISE SHEET

5.3 Concentration Over Time

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

Objective

Build the skills to answer exam questions on **concentration over time** —the integrated rate laws.

You must be able to:

- recognise a **zero, first, or second order** reaction from a straight-line plot
- use the **half-life** 半衰期 of a first-order reaction
- know which graph is linear for each order

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

Which plot is linear

- **Zero order**: [A] vs t is a straight line.
- **First order**: ln[A] vs t is a straight line.
- **Second order**: $\frac{1}{[\mathrm{A}]}$ vs t is a straight line.

Test data by seeing which plot gives a straight line —that reveals the order.

The slope gives k

For first order, $\ln[\mathrm{A}] = -kt + \ln[\mathrm{A}]_0$: the slope is $-k$. For second order, the slope of $\frac{1}{[\mathrm{A}]}$ vs t is $+k$.

First-order half-life

A first-order reaction has a **constant** half-life:

$$t_{1/2} = \frac{0.693}{k}.$$

It takes the same time to halve, over and over —independent of the starting amount.

A worked half-life

If $k = 0.0347\ \mathrm{s}^{-1}$, then $t_{1/2} = \frac{0.693}{0.0347} = 20\ \mathrm{s}$.

2 Practice

Now apply the methods above.

2.1 Which plot is linear for a first-order reaction? [1]

2.2 Find the half-life of a first-order reaction with $k = 0.100\ \text{s}^{-1}$. [2]

2.3 For a first-order reaction, does the half-life depend on the starting concentration? [1]

3 Exam-style questions

3.1 A plot of $\frac{1}{[\text{A}]}$ vs time is linear. The reaction is [1]

- **A** zero order
- **B** first order
- **C** second order
- **D** third order

3.2 A first-order reaction has a half-life of 30 s.

(a) Find the rate constant k. [2]

(b) What fraction of the reactant remains after 60 s? [2]

3.3 A student plots [A], ln[A], and $\frac{1}{[\text{A}]}$ against time; only the ln[A] plot is straight. State

the order and how to find k from the graph. [2]

4 Go further

You are now ready for the real exam questions on this subtopic:

- work through the **5.3 Concentration Over Time** lesson on the **Learn** page;
- read the **Concentration Over Time** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 ln[A] vs t.

2.2 $t_{1/2} = \dfrac{0.693}{0.100} = 6.93$ s.

2.3 No —it is constant (independent of starting concentration).

3.1 C —a linear $\frac{1}{[\mathrm{A}]}$ plot means second order.

3.2 (a) $k = \dfrac{0.693}{30} = 0.0231\ \mathrm{s}^{-1}$. (b) 60 s is two half-lives, so $\left(\frac{1}{2}\right)^2 = \frac{1}{4}$ remains.

3.3 First order; the slope of the ln[A] vs t line is $-k$.