- Briefly explain why a radionuclide used in diagnostic work should have a short half-life.

  The half life should be short enough to rid the body of radioactivity before damage occurs. (It must also be long enough to allow the compound containing the radionuclide to be made and administered).

- Briefly explain why alpha emitters are not used in diagnostic work.

  Because of their high mass and charge, alpha particles interact strongly with tissue and cause potentially damaging ionization if inside the body.
Consider the results of the following set of experiments studying the rate of the chemical reaction: $2A + B \rightarrow 3C + D$

<table>
<thead>
<tr>
<th>Experiment #</th>
<th>initial [A] / M</th>
<th>initial [B] / M</th>
<th>Rate / M hr$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.240</td>
<td>0.120</td>
<td>2.00</td>
</tr>
<tr>
<td>2</td>
<td>0.120</td>
<td>0.120</td>
<td>0.500</td>
</tr>
<tr>
<td>3</td>
<td>0.240</td>
<td>0.060</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Write the rate law expression.

Between experiment 1 and 2, [B] is kept constant. [A] is halved which causes the rate to be reduced by a factor of four. The rate is second order with respect to [A].

Between experiment 1 and 3, [A] is kept constant. [B] is halved which causes the rate to halve. The rate is first order with respect to [B]. Thus,

$$\text{rate} \propto [A]^2[B] = k[A]^2[B]$$

Rate $= k[A]^2[B]$

Calculate the rate constant, $k$, with units.

Using experiment 1 and rate $= k[A]^2[B]$:

$$\text{(2.00 M hr}^{-1}) = k \times (0.240 \text{ M})^2 \times (0.120 \text{ M}) \quad \text{so } k = 289 \text{ M}^2 \text{ hr}^{-1}$$

$$\text{(M hr}^{-1}) = (\text{units of } k) \times (\text{M})^2 \times (\text{M}) \quad \text{so the units of } k \text{ are M}^2 \text{ hr}^{-1}$$

$k = 289 \text{ M}^2 \text{ hr}^{-1}$

What is the rate of the reaction when [A] is 0.0140 M and [B] is 1.35 M?

Using rate $= (289 \text{ M}^2 \text{ hr}^{-1})[A]^2[B]$, the rate is:

$$\text{rate} = (289 \text{ M}^2 \text{ hr}^{-1}) \times (0.0140 \text{ M})^2 \times (1.35 \text{ M})$$
$$= 0.0766 \text{ M hr}^{-1} = 7.66 \times 10^{-3} \text{ M hr}^{-1}$$

Rate $= 7.66 \times 10^{-3} \text{ M hr}^{-1}$
Consider the following two compounds.

(I) Martius Yellow  (II) Naphthol Yellow S

On ingestion of compound (I), death from liver failure occurs very quickly. In contrast, compound (II) is completely non-toxic and is used as an artificial colouring agent. Explain, using the model of biological membranes, why (I) is highly toxic.

Naphthol Yellow S is water soluble, so does not pass through the cell membrane. The hydrophilic region of the lipid bilayer acts as an impermeable barrier.

Martius Yellow is non-polar so may pass through the cell membrane. It can either disrupt the function of the cell membrane itself, or pass into the cell and damage the various parts of the liver cells.

Give three examples of colloids in biological systems, and complete the following table. Paint is given as an example of a synthetic (non-biological) system.

<table>
<thead>
<tr>
<th>Name of colloid</th>
<th>Discrete phase</th>
<th>Continuous phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>paint</td>
<td>synthetic polymer</td>
<td>water</td>
</tr>
<tr>
<td>blood</td>
<td>red blood cells</td>
<td>water/plasma</td>
</tr>
<tr>
<td>milk</td>
<td>casein</td>
<td>water</td>
</tr>
<tr>
<td>cell</td>
<td>nucleus, ribosomes etc</td>
<td>cell fluid/cyttoplasm</td>
</tr>
</tbody>
</table>
Describe how hydrophilic and hydrophobic colloids are stabilised in water.

They can be stabilised via electrostatic and steric stabilisation.

Hydrophilic colloids may have a charge on their surface that attracts oppositely charged ions (H\(^+\) or OH\(^-\) present in water) to form a tightly bound layer known as the Stern Layer. The Stern layer is surrounded by a diffuse layer which contains an excess of counter-ions (opposite in charge to the Stern layer) and a deficit of co-ions. The Stern layer and diffuse layer are collectively known as a double layer. Coagulation of a hydrophilic colloid is prevented by mutual repulsion of the double layers.

Hydrophobic colloids may be stabilised by the use of a surfactant, e.g. a long chain fatty acid with a polar head and a non-polar tail. When dispersed in water these molecules arrange themselves spherically so that the polar (hydrophilic) heads are interacting with the polar water molecules and the non-polar (hydrophobic) tails are interacting with each other. This arrangement is called a micelle. The hydrophobic colloid can be stabilized by dissolving in the non-polar interior of the micelle.
If a medical procedure calls for 1.0 mg of $^{128}\text{Ba}$, how much isotope would be required to be able to use it exactly one week later? The half-life of $^{128}\text{Ba}$ is 2.43 days.

The decay constant, $\lambda$, is related to the half life, $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{2.43 \text{ days}} = 0.285 \text{ days}^{-1}$. The number of radioactive nuclei present reduces with time according to:

$$\ln \left( \frac{N_0}{N_t} \right) = \lambda t$$

With a decay constant, $\lambda = 0.285 \text{ days}$, and $N_t = 1.0 \text{ mg}$ for $t = 7 \text{ days}$, the amount originally present would have to be:

$$\ln \left( \frac{N_0}{(1.0 \times 10^{-3} \text{ g})} \right) = 0.285 \times 7$$

$$N_0 = 0.0074 \text{ g} = 7.4 \text{ mg}$$

Answer: 7.4 mg