Marks 7

- Four experiments were conducted to discover how the initial rate of consumption of BrO_3^- ions in the reaction below varied as the concentrations of the reactants were changed.

$$BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$$

Experiment	Initial concentration (mol L^{-1})			Initial rate
	BrO_3^-	Br^-	H^+	(mol L^{-1} s^{-1})
1	0.10	0.10	0.10	1.2×10^{-3}
2	0.20	0.10	0.10	2.4×10^{-3}
3	0.10	0.30	0.10	3.5×10^{-3}
4	0.20	0.10	0.15	5.4×10^{-3}

Use the experimental data in the table above to determine the order of the reaction with respect to *each* reactant.

Between experiments (1) and (3), $[Br^-]$ and $[H^+]$ are kept constant but $[BrO_3^-]$ is doubled. This doubles the rate: the rate is proportional to $[BrO_3^-]^1$ and so is first order with respect to BrO_3^-.

Between experiments (2) and (4), $[BrO_3^-]$ and $[Br^-]$ are kept constant but $[H^+]$ is increased by a factor of (0.15/0.10) = 1.5. This increases the rate by a factor of (5.4×10^{-3} / 2.4×10^{-3}) = 2.25: the rate is proportional to $[H^+]^2$ as $(1.5)^2 = 2.25$ and so is second order with respect to H^+.

Between experiments (1) and (2), $[BrO_3^-]$ and $[H^+]$ are kept constant but $[Br^-]$ is increased by a factor of 3. This increases the rate by a factor of (3.5×10^{-3} / 1.2×10^{-3}) = 2.9: the rate is proportional to $[Br^-]^1$ and so is first order with respect to Br^-.

Overall,

rate = $k[BrO_3^-][Br^-][H^+]^2$

What is the rate of formation of Br_2 when $[BrO_3^-] = [Br^-] = [H^+] = 0.10$ M?

From the table, when $[BrO_3^-] = [Br^-] = [H^+] = 0.10$ M, the rate of consumption of BrO_3^- is 1.2×10^{-3} M s^{-1}. From the chemical equation, Br_2 is produced at three times this rate.

The rate of production of Br_2 is 3.6×10^{-3} M s^{-1}.

Write the rate law for the reaction and determine the value of the rate constant, *k*.

From above, rate = $k[BrO_3^-][Br^-][H^+]^2$. Using experiment (1):

ANSWER CONTINUES ON THE NEXT PAGE

rate = $k[BrO_3^-][Br^-][H^+]^2$
= $k(0.10\ M)(0.10\ M)(0.10\ M)^2 = k(0.00010\ M^4) = 1.2 \times 10^{-3}\ M\ s^{-1}$

So,

$k = (1.2 \times 10^{-3}\ M\ s^{-1}) / (0.00010\ M^3) = 12\ M^{-3}\ s^{-1}$