

Read questions carefully before answering. No outside paper is allowed. Write **set up equation** for a mathematical problem, then put the raw data with **units**, before showing the calculation. Use the reverse side of your answer paper as scratch. Use the periodic table and important constants charts provided. (Total points = $44 + (22 \times 3) = 110$).

Show your calculation with set up and units (when appropriate)

- 1) An aqueous solution contains 3.62 mass % of NaOCl. Calculate (a) the molality (4 pts.) of NaOCl in the solution. (4 pts.)

1) 0.49 m

Assume solution mass = 100g = 0.1 kg

Mass of solute = mass NaOCl = 3.62 g

$3.62 \text{ g} \times \frac{1 \text{ mole}}{74.5 \text{ g NaOCl}} = 0.049 \text{ mol NaOCl}$

molality = $\frac{\text{mole of solute}}{\text{wt. of solvent in Kg}}$

$= \frac{3.62\% (23+16+35.45) \text{ g/mol}}{(100-3.62) \text{ g} \times \frac{1 \text{ Kg}}{1000 \text{ g}}}$
 $= \frac{0.04862 \text{ mol}}{0.09638 \text{ Kg}} = 0.504 \text{ mol/mol}$

molality = $\frac{0.049 \text{ mol NaOCl}}{0.1 \text{ Kg (soln) (No)}} = 0.49 \text{ m}$

- (b) Calculate the mole fraction of NaOCl in the aqueous solution (4 pts.)

mass of water: $100 \text{ g} - 3.62 \text{ g} = 96.38 \text{ g}$

$96.38 \text{ g} \times \frac{1 \text{ mol}}{18 \text{ g H}_2\text{O}} = 5.35 \text{ mol H}_2\text{O}$

$X_{\text{NaOCl}} = \frac{0.049 \text{ mol NaOCl}}{0.049 \text{ mol NaOCl} + 5.35 \text{ mol H}_2\text{O}} = 9.1 \times 10^{-3}$

- 2) What mass (in kilogram) of CaCl_2 is needed to decrease FP of 11000.0 g of water to -5.5°C . (Assume CaCl_2 dissolves completely and it has an ideal van't Hoff factor. K_{fp} for water is -1.86°C/m .) *8 pts.)

2) 1.21 Kg CaCl_2

$\Delta T_f = -5.5^\circ\text{C} - 0^\circ\text{C}$
 $= -5.5^\circ\text{C}$



$\Delta T_f = K_f \times m \times i$

$\Rightarrow m = \frac{|\Delta T_f|}{K_f \times i} = \frac{-5.5^\circ\text{C}}{-1.86^\circ\text{C/m} \times 3} = 0.99 \text{ m}$

$m = \frac{\text{moles of CaCl}_2}{\text{Kg water}} \Rightarrow \text{moles of CaCl}_2 = m \times \text{Kg water}$

$= 0.99 \text{ m} \times 11000.0 \text{ g} \times \frac{1 \text{ Kg}}{1000 \text{ g}}$

$= 10.89 \text{ moles}$

mass of $\text{CaCl}_2 = 10.89 \text{ mol} \times \frac{111 \text{ g}}{1 \text{ mol}} \times \frac{1 \text{ Kg}}{1000 \text{ g}} = 1.21 \text{ Kg CaCl}_2$

$$\text{Rate} = k.[A]^m[B]^n$$

3) The initial rate of the reaction $A + B \rightarrow C$ was measured at several different concentrations of the reactants. Following formal methods, (a) calculate the rate law for the reaction (6 pts.) and (b) The magnitude of the rate constant (4 pts.).

3) $4 \times 10^{-3} \text{ M}^{-1} \text{ s}^{-1}$

Experiment	Initial Concentrations		Initial Rate (M s^{-1})
	[A] (M)	[B] (M)	
1	0.10	0.10	4.0×10^{-5}
2	0.10	0.20	4.0×10^{-5}
3	0.20	0.10	16.0×10^{-5}

$$\frac{\text{Rate 2}}{\text{Rate 1}} = \frac{k[0.1]^m[0.20]^n}{k[0.1]^m[0.1]^n} = \left(\frac{0.2}{0.1}\right)^n = 2^n = \frac{4.0 \times 10^{-5}}{4.0 \times 10^{-5}} = 1 \Rightarrow 2^n = 1 \Rightarrow \log 2^n = \log 1$$

$$n \cdot \log 2 = \log 1$$

$$n = 0 \checkmark$$

$$\frac{\text{Rate 3}}{\text{Rate 1}} = \frac{k[0.2]^m[0.1]^n}{k[0.1]^m[0.1]^n} = \left(\frac{0.2}{0.1}\right)^m = 2^m = \frac{16 \times 10^{-5}}{4 \times 10^{-5}} = 4 \Rightarrow 2^m = 4 \Rightarrow \log 2^m = \log 4$$

$$m \cdot \log 2 = \log 4$$

$$m = 2 \checkmark$$

\Rightarrow Rate law: $\text{rate} = k.[A]^2 \Rightarrow k = \frac{\text{rate}}{[A]^2} = \frac{4 \times 10^{-5} \text{ M} \cdot \text{s}^{-1}}{(0.1 \text{ M})^2} = 4 \times 10^{-3} \text{ M}^{-1} \cdot \text{s}^{-1} \checkmark$

4) The reaction $2 \text{NO}_2(\text{g}) \rightarrow 2 \text{NO}(\text{g}) + \text{O}_2(\text{g})$ is 2nd order in $[\text{NO}_2]$ at 300°C with $k = 0.543 \text{ M}^{-1} \text{ s}^{-1}$; If in a closed container, the initial concentration of $\text{NO}_2 = 0.05 \text{ M}$ then calculate the concentration of NO_2 after half an hour at that temperature (6 pts.). [Note: For 2nd order kinetics: $1/[A]_t = k \cdot t + 1/[A]_0$]

4) $1.00 \times 10^{-3} \text{ M}$

$$\frac{1}{[A]_t} = k \cdot t + \frac{1}{[A]_0}$$

$$\frac{1}{[A]_t} = (0.543 \text{ M}^{-1} \text{ s}^{-1}) \times \left(30 \text{ min} \times \frac{60 \text{ s}}{1 \text{ min}}\right) + \frac{1}{0.05 \text{ M}}$$

$$= 977.4 \text{ M}^{-1} + 20 \text{ M}^{-1}$$

$$= 997.4 \text{ M}^{-1}$$

$$\Rightarrow \frac{1}{[A]_t} = 997.4 \text{ M}^{-1}$$

$$[A]_t = \frac{1}{997.4 \text{ M}^{-1}} = 1.00 \times 10^{-3} \text{ M} \checkmark$$

