1) The rate constant of a certain reaction is $k = 6.0 \times 10^{-2}\ M^{-1}s^{-1}$. If the reaction began with a substance of concentration 0.20 M, determine the substance's half life.

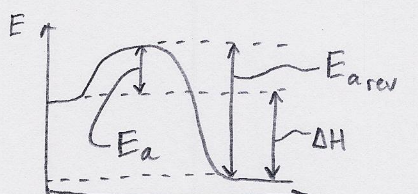
$[k] = [M^{-1}][s^{-1}]$ ∴ 2nd order!

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$t_{1/2} = \frac{1}{(6.0\times10^{-2}M^{-1}s^{-1})(0.20M)} = \boxed{83\ s}$$

2) For a certain reaction, the activation energy is 675 KJ/mol, and the change in enthalpy is −50 KJ/mol. Find the activation energy of the reverse reaction.

$\Delta H = -50$ KJ/mol ∴ exothermic!



$$E_{a_{rev}} = E_a + |\Delta H|$$
$$= (675\ KJ/mol) + |-50\ KJ/mol|$$
$$\boxed{E_{a_{rev}} = 725\ KJ/mol}$$

3) Write the equilibrium constant:

$$4A\ (aq) + 6B\ (s) \rightleftharpoons 5C\ (l) + 16D\ (g)$$

$K_c = \frac{\text{products}}{\text{reactants}}$ (ignoring pure liquids and solids)

$$\boxed{K_c = \frac{[D]^{16}}{[A]^4}}$$

4) Determine the intermediate(s) in the following reaction mechanism:

$$\cancel{A} + B \rightarrow \cancel{C}$$

$$\cancel{C} + D \rightarrow E + \cancel{F}$$

$$D + \cancel{F} \rightarrow \cancel{A} + G$$

$$B + 2D \rightarrow E + G$$

A is a catalyst

C and F are intermediates

5) What is the molecularity of the following elementary reaction?

$$A + A + B \rightarrow C$$

termolecular

6) Given the rate of formation of C_2H_5OH is 0.30 M/s, determine the rate of consumption of $C_6H_{12}O_6$:

$$C_6H_{12}O_6\,(aq) \rightarrow 2C_2H_5OH + 2CO_2\,(g)$$

$$\text{General Rate of Rxn} = \frac{\text{R of } C_2H_5OH}{\text{coefficient of } C_2H_5OH}$$

$$\text{''} \quad \text{''} = \frac{0.30\text{ M/s}}{2} = 0.15\text{ M/s}$$

Rate of $C_6H_{12}O_6$ = General Rate = **0.15 M/s** (1:1 ratio)

7) Radioactive ^{241}Pu has a half life of 14 years. Assuming it decays according to 1st order kinetics, determine how long it takes for 20% of the starting amount to decay.

$t_{1/2} = 14$ yrs, % remaining = 80%

$\therefore \frac{[A]_t}{[A]_0} = 0.80$

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

$$k = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{14\,yr}$$

$$k = 4.95 \times 10^{-2}\,yr^{-1}$$

$$\ln[A]_t = -kt + \ln[A]_0$$

$$\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$$

$$t = \frac{-\ln\left(\frac{[A]_t}{[A]_0}\right)}{k} = \frac{-\ln(0.80)}{4.95\times10^{-2}\,yr^{-1}} \Rightarrow \boxed{t = 4.5\,yr}$$

8) 2 moles of H_2O_2 are placed into a 4 L container, and the following reaction proceeds with a rate constant of $2.1 \times 10^{-6}\,s^{-1}$! What is the concentration of H_2O_2 35 minutes after the reaction begins?

$$2H_2O_2\,(aq) \rightarrow 2H_2O\,(l) + O_2\,(g)$$

$[k] = [s^{-1}]$ $\therefore$ 1st order!

$$\ln[A]_t = -kt + \ln[A]_0$$

$$[H_2O_2]_t = e^{[-kt + \ln[H_2O_2]_0]}$$

$$[H_2O_2]_{35} = e^{\left[-(2.1\times10^{-6}\,s^{-1})(35\,min)\left(\frac{60\,s}{1\,min}\right) + \ln\left[\frac{2\,mol}{4\,L}\right]\right]}$$

$$[H_2O_2]_{35} = 0.498\,M \approx \boxed{0.5\,M\ (rounded)}$$

9) Given:

① $A + 2B \rightleftharpoons C$ $\quad K_{eq_1} = 6.1 \times 10^{2}$

② $3X + 5Y \rightleftharpoons 2Z$ $\quad K_{eq_2} = 2.3 \times 10^{-1}$

What is K_{eq_3} for:

③ $3A + 6B + 2Z \rightleftharpoons 3C + 3X + 5Y$?

③ = [3×①] + [reverse ②]

$$\therefore K_{eq_3} = [K_{eq_1}]^3 \times \left[\frac{1}{K_{eq_2}}\right]$$

$$K_{eq_3} = [6.1 \times 10^{2}]^3 \times \left[\frac{1}{2.3 \times 10^{-1}}\right] \Rightarrow \boxed{K_{eq_3} = 9.9 \times 10^{8}}$$

10) Find K_p of the following reaction given $K_c = 4.1 \times 10^{2}$ at 16.2°C:

$$H_2O\,(l) + CH_4\,(g) \rightleftharpoons CO\,(g) + 3H_2\,(g)$$

$$K_p = K_c\,(RT)^{\Delta n\,(\text{mol gas})}$$

$$K_p = [4.1 \times 10^{2}]\left([0.08206][16.2 + 273.15]\right)^{([3\,\text{mol}\,H_2 + 1\,\text{mol}\,CO] - [1\,\text{mol}\,CH_4])}$$

$$K_p = [4.1 \times 10^{2}]\left([0.08206][289.35]\right)^{3}$$

$$\boxed{K_p = 5.5 \times 10^{6}}$$

11) Credit: utexas.edu

Given:

Trial	[A]	[B]	Rate
1	0.1 M	0.1 M	1×10^{-4} M/s
2	0.1 M	0.2 M	1×10^{-4} M/s
3	0.3 M	0.1 M	3×10^{-4} M/s

Determine:

a) Order with respect to A

b) Order with respect to B

c) Rate constant

a) $\frac{Rate_3}{Rate_1} = \frac{k[A]_3^x[B]_3^y}{k[A]_1^x[B]_1^y} \Rightarrow \frac{3\times10^{-4} M/s}{1\times10^{-4} M/s} = \frac{\cancel{k}[0.3M]^x\cancel{[0.1M]^y}}{\cancel{k}[0.1M]^x\cancel{[0.1M]^y}}$

$3 = 3^x$

$\boxed{x = 1}$

b) $\frac{Rate_2}{Rate_1} = \frac{k[A]_2^x[B]_2^y}{k[A]_1^x[B]_1^y} \Rightarrow \frac{1\times10^{-4} M/s}{1\times10^{-4} M/s} = \frac{\cancel{k}\cancel{[0.1M]^x}[0.2M]^y}{\cancel{k}\cancel{[0.1M]^x}[0.1M]^y}$

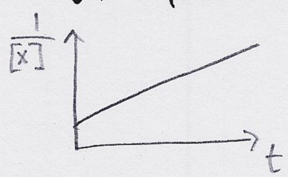
$1 = 2^y$

$\boxed{y = 0}$

c) $Rate_1 = k[A]_1^x[B]_1^y \Rightarrow 1\times10^{-4} M/s = k[0.1M]^1\cancel{[0.1M]^0}$

$k = \frac{1\times10^{-4} M/s}{0.1 M} = \boxed{1\times10^{-3}\ s^{-1}}$

12) A graph of $\frac{1}{[X]}$ vs. time generates a linear plot for the reaction $X \rightarrow Y$. Determine the differential rate law of the reaction.



∴ 2nd order

$$\boxed{\text{Rate} = k[X]^2}$$

13) Calculate the equilibrium concentrations of H_2, I_2, and HI at 700 K if the initial concentrations are:

$$[H_2]_0 = 0.100\text{ M}\ ,\quad [I_2]_0 = 0.200\text{ M}$$

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad K_c = 57.0$$

	H_2	I_2	$2HI$
[I]	0.100 M	0.200 M	∅
[C]	−x	−x	+2x
[E]	(0.100 M − x)	(0.200 M − x)	(2x)

$$K_c = \frac{[HI]^2}{[H_2][I_2]}$$

$$57.0 = \frac{(2x)^2}{(0.1-x)(0.2-x)}$$

$$57.0[(0.1-x)(0.2-x)] = 4x^2$$

$$57.0[0.02 - 0.1x - 0.2x + x^2] = 4x^2$$

$$57.0x^2 - 17.1x + 1.14 = 4x^2$$

$$53.0x^2 - 17.1x + 1.14 = 0$$

→ $$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-(-17.1) \pm \sqrt{(-17.1)^2 - 4(53.0)(1.14)}}{2(53.0)}$$

$x =$ ~~0.229 M~~, 0.0943 M

↳ can't have larger than $[H_2]_0$!

$[H_2]_{eq} = 0.100\text{ M} - (0.0943\text{ M}) = \boxed{0.006\text{ M}}$

$[I_2]_{eq} = 0.200\text{ M} - (0.0943\text{ M}) = \boxed{0.106\text{ M}}$

$[HI]_{eq} = 2(0.0943\text{ M}) = \boxed{0.189\text{ M}}$

14) A certain reaction has an activation energy of 43.165 KJ/mol.

How much faster will the reaction proceed at 600 Kelvin than at 419 Kelvin?

(Round to nearest whole number).

*If $Rate_2$ was 5 times faster than $Rate_1$: $R_2 = 5 \cdot R_1$

$$5 = \frac{R_2}{R_1}$$

$$5 = \frac{k_2 [A]^x [B]^y}{k_1 [A]^x [B]^y}$$

$5 = k_2/k_1$

↳ This ratio is what we want!

let $X = \frac{R_2}{R_1} = \frac{k_2}{k_1}$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{-E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln(x) = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$X = e^{\left[-\frac{(43.165\ kJ/mol)\left(\frac{1000\ J}{1\ kJ}\right)}{8.3145\ J/mol\,K}\left(\frac{1}{600K} - \frac{1}{419K}\right)\right]}$$

X = 42 times faster !

15) Devise a mechanism for the following overall reaction given it's experimental rate law is $R = k[NO_2]^2$:

$$NO_2\,(g) + CO\,(g) \rightarrow NO\,(g) + CO_2\,(g)$$

$NO_2 + NO_2 \xrightarrow{k_1} NO + NO_3$	(slow)	$R_1 = k_1[NO_2]^2$
$CO + NO_3 \xrightarrow{k_2} CO_2 + NO_2$	(fast)	

16) Given $[H_2] = 0.05\ M$, $[I_2] = 0.15\ M$, and $[HI] = 0.42\ M$, which direction will the following reaction proceed?

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \quad K_c = 57.0$$

$$Q = \frac{[HI]^2}{[H_2][I_2]} = \frac{(0.42M)^2}{(0.05M)(0.15M)} = 23.5$$

$23.5 < 57.0$

$\therefore$ $Q < K_c$

$\therefore$ reaction proceeds to the **right**

17) For the reaction at equilibrium:

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

a) What happens to $[CO_2]$ when $CaCO_3$ is added?

b) What happens to the amount of $CaCO_3$ when some $CO_2(g)$ is removed?

a) $Q = [CO_2]$, if we add $CaCO_3$, Q doesn't change, therefore **Nothing** happens to $[CO_2]$

b) $Q = [CO_2]$, if we remove CO_2, Q decreases, then $Q < K_{eq}$, shift right, **$CaCO_3$ decreases**

18) For the reaction at equilibrium in a sealed container:

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

Which direction will the reaction shift if the volume of the container decreases?

$$Q = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{\left(\frac{mol\ NH_3}{L}\right)^2}{\left(\frac{mol\ N_2}{L}\right)\left(\frac{mol\ H_2}{L}\right)^3} = \left(\frac{mol\ NH_3^2}{L^2}\right)\cdot\left(\frac{L}{mol\ N_2}\right)\left(\frac{L^3}{mol\ H_2^3}\right)$$

$$Q = \frac{(mol\ NH_3)^2}{(mol\ N_2)(mol\ H_2)^3}\cdot L^2$$

$Q \propto (volume)^2$ ∴ If volume decreases, Q decreases then $Q < K_{eq}$, shifts **right**

19) In order to maximize yield of products, would you increase or decrease the temperature of the following rxn at equilibrium?

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g) \quad \Delta H^\circ = 57.2\ KJ$$

ΔH is positive, ∴ endothermic!
↳ heat can be treated like a reactant.

$$heat + N_2O_4 \rightleftharpoons 2NO_2$$

put in more heat to push reaction towards the products side

∴ **Increase Temp**