THE INTERNATIONAL UNIVERSITY (IU) – VIETNAM NATIONAL UNIVERSITY – HCMC

CHEMISTRY FOR ENGINEERS

ASSIGNMENT 4

Date:

Duration:

Part I: CONSTRUCTED QUESTIONS (70pts)

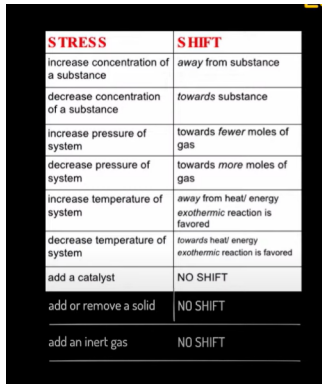
1. (20pts) Given the reverse reaction:

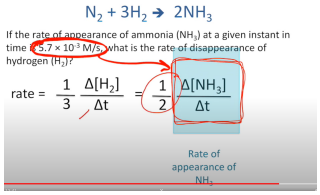
$$2H_2\,(g) + O_2\,(g) \rightleftarrows 2H_2O\,(g) \quad ; \Delta H^o = -242\ kJ/mol$$

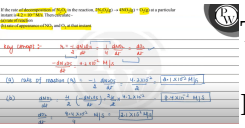
(+ heat; this mean heat is product)

List all below factors that shift reaction to right (forward reaction):

a) Increase temperature;
b) Decrease temperature;
c) Hít hà all O_2; (add)
d) Remove H_2;
e) Use all water to make cocktail;
f) Supply O_2 by photosynthesis in plant;
g) Maintain H_2O concentration;
h) Use catalyst;
i) Steal H_2 form rocket and supply to this reaction;
j) Increase pressure of the system.







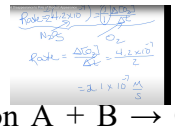
The decomposition of N_2O_5 proceeds according to the following equation:

$$2\,N_2O_5\,(g) \rightarrow 4\,NO_2\,(g) + O_2\,(g)$$

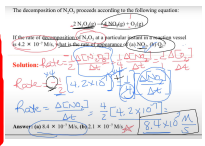
rate of H_2 disappearance = $\frac{3}{2}(5.7 \times 10^{-3}\ M/s)$

If the rate of decomposition of N2O5 at a particular instant in a reaction vessel is 4.2 $\times 10^{-7}$ M/s, what is the rate of appearance of :

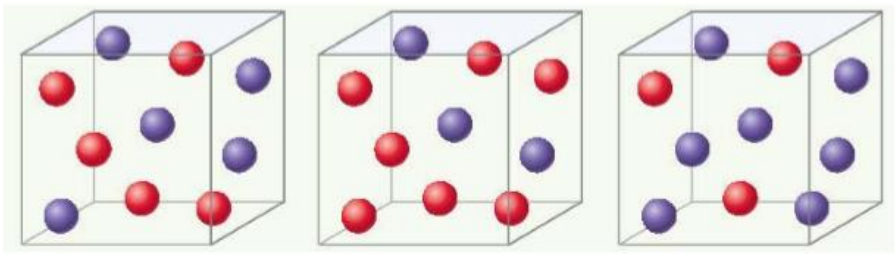
a) NO_2 (5pts)
b) O_2 (5pts)



$$rate = -\frac{1}{2}\frac{\Delta N_2O_5}{\Delta T} = \frac{1}{4}\frac{\Delta NO_2}{\Delta T} = \frac{\Delta O_2}{\Delta T}$$



??? 3. Consider a reaction A + B → C for which = k[A][B]^2. Each of the following boxes



represents a reaction mixture in which A is shown as red spheres and B as purple ones. Rank these mixtures in order of increasing rate of reaction and show your answer. (10pts)

Box 1 contains 5 red spheres and 5 purple spheres, giving the following rate:

Box 1: Rate = $k(5)(5)^2 = 125k$

Box 2 contains 7 red spheres and 3 purple spheres:

Box 2: Rate = $k(7)(3)^2 = 63k$

Box 3 contains 3 red spheres and 7 purple spheres:

Box 3: Rate = $k(3)(7)^2 = 147k$

The slowest rate is $63k$ (box 2), and the highest is $147k$ (box 3). Thus, the rates vary in the order 2 < 1 < 3.

Box1 : $K(5 \times 25) = 125K$

Box2 : $K(7 \times 9) = 63K$ => $2 < 1 < 3$

Box3 : $K(3 \times 49) = 147K$

a) $Rate = K[NO]^x[H_2]^y$

$x = 2$, $y = 1$ } overall rate order $= 2 + 1 = 3$

$\Rightarrow Rate = K[NO]^2[H_2]$

4. The following data were measured for the reaction of nitric oxide with hydrogen:

$$2\ NO\ (g) + 2H_2\ (g) \rightarrow N_2\ (g) + 2\ H_2O\ (g)$$

EXPERIMENT NUMBER	[NO] (M)	[H2] (M)	INITIAL RATE (M/S)
1	0.10	0.10	1.23×10^{-3}
2	0.10	0.20	2.46×10^{-3}
3	0.20	0.10	4.92×10^{-3}

$\frac{M}{S} \times \frac{1}{M^3} = \frac{1}{S \cdot M^2}$

$2^x = 4$ $\quad 2^y = 2$

a) Determine the rate law for this reaction by showing your calculation. (6pts)

b) Calculate the rate constant. (4pts)

b) $K = \frac{Rate}{[NO]^2[H_2]} = \frac{1.23 \times 10^{-3}}{(0.10)^2 \times 0.10} = 1.23\ \frac{1}{S \cdot M^2}$

??? 5. In a close container with 1 mol/L of ammonia at 0°C, 1atm. Heat this container to 546°C with the decomposition reaction of ammonia. When this reaction reaches equilibrium, pressure in container is 3.3 atm. Calculate the equilibrium constant of decomposition reaction. Assume that the volume not change. (5pts)

$$2NH_3 \rightleftarrows N_2 + 3H_2$$

$n = 0.1 \times 0.025 = 2.5 \times 10^{-3}$ moles

5)

$2NH_3 \rightleftarrows N_2 + 3H_2$

Initial	1	0	0
Change	2x	x	3x
Equilibrium	1 – 2x	x	3x

$N_2.T1/P1 = N_2.T2/P2$

$\Rightarrow 273 = (1-2x+x+3x).819/3,3$

$\Rightarrow 273 = (1+2x).819/3,3$

$\Rightarrow x = 0.05$

$Kc = [N_2].[H_2]^2/[NH_3]^3 = 2,08.10^{-4}$

6. Calculate the pH of acetate buffer after mixing 25.00 mL of sodium acetate 0.10M with 50.00 mL of acetic acid, CH_3COOH, 0.20M. The temperature is 25°C. (10pts)

CH3COONa

CH3COOH

Given: Ka value for acetic acid at 25°C is 1.80×10^{-5}.

$n = 0.20 \times 0.05 = 0.01$ moles | total volume: $0.025 + 0.05 = 0.075$ L

$C_{[A^-]} = \frac{2.5 \times 10^{-3}}{0.075} = 0.033\ M$

??? 7. The reaction is believed to occur in two steps:

$O_3\ (g) + NO_2\ (g) \rightarrow NO_3\ (g) + O_2\ (g)$ slow

$NO_3\ (g) + NO_2\ (g) \rightarrow N_2O_5\ (g)$ fast

The experimental rate law is rate = $k[O_3][NO_2]$. What can you say about the relative rates of the two steps of the mechanism? (5pts)

it is first order w.r.t. to both reactants.

- Because the rate law conforms to the molecularity of the first step which must be the rate-determining step. The second step must be faster than the first one.

- The experimental rate law rate = k[O3][NO2] suggests that the rate of the reaction depends on the concentrations of O3 and NO2. This implies that the first step of the mechanism, O3 (g) + NO2 (g) → NO3 (g) + O2 (g), is the rate-determining step. The second step, NO3 (g) + NO2 (g) → N2O5 (g), is faster and does not affect the overall rate of the reaction.

$pH = pKa + \log\left(\frac{[A^-]}{[HA]}\right)$

$C_{[HA]} = \frac{0.01}{0.075} = 0.1M$

$pKa = -\log(Ka)$

$= 4.74$

$pH = 4.13$

Henderson-Hasselbalch equation

$pH = pK_a + \log \frac{[\text{conjugate base}]}{[\text{acid}]}$

Part II: MULTIPLE CHOICE (30pts)

There may be more than or equal 0 and less than or equal 21 **INCORRECT** answers. But, unfortunately, I forget how many incorrect numbers, so please remind me by giving exact number:

A. 5	B. 7	C. 9
D. 11	E. 13	F. Your answer:_____

List of statements:

a) The rate of a chemical reaction changes with time.

b) The rate constant of a reaction generally depends on the concentrations of species.

c) The function of buffer is to resist the change in pOH.

d) Chemical equilibrium exists when the two opposite reactions occur simultaneously at the same rate.

e) In the Lowry-Bronsted theory a base is an OH^- donor. A base is not necessarily an OH- donor

f) The reaction order is experimentally determined.

g) Temperature cannot affect the rate of a chemical reaction

h) When a catalyst is used in a reaction, it does not affect the final amounts of reactants and products.

i) The value of the equilibrium constant for the reaction $K_c = 1.26 \times 10^{-12}$ at 500 K implies the product concentrations will be large relative to the reactants at equilibrium.

j) Equilibrium is achieved when the reactant and product concentrations become equal.

k) The rate law of a chemical reaction bears no relationship with the balancing coefficients of the overall reaction.

l) Introducing a catalyst can affect the value of the equilibrium constant.

m) The rate law expresses how the rate varies with concentration of species.

n) An electrolyte is a substance that dissolves in water to give an electrically non-conducting solution

p) Conjugate acid of Ac^- is HAc.

q) The half-life, t1/2, of a reaction is the time it takes for the product concentration to increase to one-half of its final value.

r) Hydration is the process that ion is surrounded by water molecules arranged in a specific manner.

s) The stronger the conjugate base is, the weaker the conjugate acid is.

t) $pOH = 14 - pK_a + \log(\frac{HA}{A^-})$

u) The units of k for the rate law:Rate = $k[A][B]^2$ is $L^2\ mol^{-2}\ s^{-1}$,when the concentration unit is mol/L.

w) Reactions usually occur at faster rates at higher temperatures.

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