1.

1. (20pts) Given the reverse reaction:

$$2H_2\ (g) + O_2\ (g) \rightleftarrows 2H_2O\ (g) \qquad ; \Delta H° = -242\ kJ/mol$$

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

a) Increase temperature;
b) Decrease temperature;
c) Hit hà all O_2;
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.

2.

a) The rate of appearance of NO2:

d[NO2]/dt = ½ d[N2O5]/dt= ½ x 4,2.10^(-7) = 2,1.10^(-7) M/s

b) The rate of appearance of O2:

d[O2]/dt = 2d[N2O5]/dt = 8,4.10^(-7) M/s

3)

- Box 1: rate = k[A][B]^2 = k.5.5^2 = 125k

- Box 2: rate = k.7.3^2 = 63k

- Box 3: rate = k.3.7^2 = 147k

=> 2 < 1 < 3

4.

a) $\text{Rate} = K[NO]^x[H_2]^y \Rightarrow \text{Rate} = K[NO][H_2]$

$\left.\begin{array}{l} x = 1 \\ y = 1 \end{array}\right\}$ overall rate order $= 1 + 1 = 2$

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}

$2^x = 2$ $\qquad 2^y = 2$

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

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

b) Calculate the rate constant. (4pts)

b) $K = \frac{\text{Rate}}{[NO][H_2]} = \frac{1.23 \times 10^{-5}}{0.10 \times 0.10} = 0.12 \ \frac{1}{S \cdot M}$

5)

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

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

N2.T1/P1 = N2.T2/P2

- ⇨ 273 = (1-2x+x+3x).819/3,3
- ⇨ 273 = (1+2x).819/3,3
- ⇨ x = 0.05

Kc = [N2].[H2]^2/[NH3]^3 = 2,08.10^-4

6.

$2NH_3 \rightleftarrows N_2 + 3H_2$

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

CH3COONa

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)
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

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.

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

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

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

$$pKa = -\log(Ka) = 4.74$$

$$pH = 4.13$$

7)

- 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.

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.

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.