Name: _____ date: _____ period: _____

ch. 10 & 14 gas & kinetics test 80 points AP chemistry

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Signature: _____

In problems involving any calculation, show your work in an organized manner, include (i) any relevant equation (or formula), (ii) conversion factor(s), (iii) put the proper units in your calculations and answer, and (iv) have the proper number of significant figures in your answer.

1. One grams of a hydrocarbon produced 3.0698 g carbon dioxide and 1.4651 g water. A 125 mL container at 85 °C and 1.0 atm with this volatile hydrocarbon was condensed to 365.7 mg liquid. What is the chemical formula and name of the hydrocarbon ? [15 points]

i) $\%\,C \text{ in } CO_2 = \frac{12}{44} = \frac{\#_g C \text{ in } CO_2}{\#_g CO_2}$; $\frac{\#_g C \text{ in } CO_2}{3.0698\,g}$; $\#_g C = 0.837_g$

ii) $\#_g H = \#_g CH - \#_g C = 1 - 0.837 = 0.162\,g$

iii) $0.837_g\,C \;\frac{mol}{12_g C} = 0.06975\,mol\,C$

$0.162\,g\,H \;\frac{mol}{1\,g\,H} = 0.162\,mol\,H$

iv)

C	:	H
0.06975	:	0.162
1	:	2 $\frac{1}{3}$
3	:	7

EF: C_3H_7

v) $n = \frac{PV}{RT} = \frac{1\,atm\,(0.125\,L)}{\left(0.0821\,\frac{L\,atm}{mol\,K}\right)(85+273)\,K} = 0.00042573\,mol$

vi) molar mass $= \frac{\#_g}{\#_{mol}} = \frac{0.3657\,g}{0.00042573\,mol} = 86\,g/mol$

vii) $n = \frac{CF}{EF} = \frac{86}{43} = 2$

viii) C_6H_{14}

hexane

2pt@ 1pt

2. At STP: 3.0 L $N_{2(g)}$ + 7.0 L $H_{2(g)}$ → $NH_{3(g)}$; the % yield is 88%; what is the experimental yield (in grams) in the reaction ? [15 points]

i) $3\,L\,N_2 \;\frac{mol}{22.4\,L} \;\frac{3\,mol\,H_2}{mol\,N_2} \;\frac{22.4\,L}{mol} = 9\,L\,H_2$ needed

∴ H_2 is limiting

ii) $7\,L\,H_2 \;\frac{mol}{22.4\,L} \;\frac{2\,mol\,NH_3}{3\,mol\,H_2} \;\frac{17\,g}{mol} = 3.54\,g$

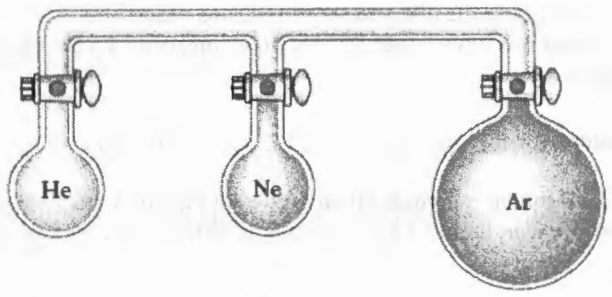
iii) $\%\,yield = \frac{expt}{calc}$

$88\% = \frac{expt}{3.54}$

$expt = 3.1\,g\,NH_3$

1pt@

3. Three flasks are connected to each other, where the pressure of He, Ne, and Ar are 825 torr, 275 torr, and 425 torr, respectively. When all of the valves / stopcocks are open, what is the __ in the system ? Assume the volume of the connecting tube is zero and the temperature in all of the flasks are the same. [10 points]



825 torr 275 torr 425 torr

a. partial pressure of helium

$P_{open} V_{open} = P_{chm} V_{chm}$

$P_{He}\ 4L = 825 \text{ torr}\ 1L$

$P_{He} = 206 \text{ torr}$

b. total pressure

i) $n_i = \frac{P_i V_i}{RT}$

ii) $P_{total} = \frac{n_{total} RT}{V_{total}} = \frac{(n_{He} + n_{Ne} + n_{Ar}) RT}{V_{total}}$

$= \frac{\left(\frac{P_{He} V_{He}}{RT} + \frac{P_{Ne} V_{Ne}}{RT} + \frac{P_{Ar} V_{Ar}}{RT}\right) RT}{V_{total}}$

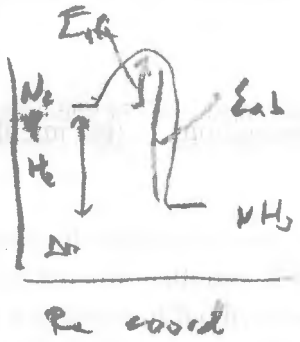
$= \frac{P_{He} V_{He} + P_{Ne} V_{Ne} + P_{Ar} V_{Ar}}{V_{total}}$

$= \frac{825(1) + 275(1) + 425(2)}{4} \text{ torr} = 1488 \text{ torr}$

$3H_2 + N_2 \rightarrow 2NH_3$ $E_{a,f} = 25\ kJ/mol_{rxn}$

4. If the activation energy of the formation of gaseous ammonia from gaseous hydrogen and nitrogen is 25 kJ / mole reaction, then what is the activation energy of the decomposition of ammonia ? Sketch / label the reaction energy profile of the reaction. [10 points]

(3pt) $\Delta H = 2\Delta H_f\, NH_3 - [3\Delta H_f\, H_2 + \Delta H_f\, N_2] = 2$
$= 2(-46.19)\ kJ = -92.4\ kJ$

(4pt) 

$\Delta H = E_{a,f} - E_{a,b}$
$-92 = 25 - E_{a,b}$
$E_{a,b} = 117\ kJ/mol_{rxn}$ (3pt)

5. Based on the below experimental data

$$2NO(g) + Cl_2(g) \longrightarrow 2NOCl(g)$$

$rate = k[NO]^x[Cl_2]^y$

Trial	[NO] (mol/L)	[Cl_2] (mol/L)	$-\frac{\Delta[NO]}{\Delta t}$ ($mol\ L^{-1}\ s^{-1}$)
1	0.10	0.10	0.00300
2	0.10	0.15	0.00450
3	0.15	0.10	0.00675 ← 0.00675

source: https://openstax.org/books/chemistry-2e/pages/12-3-rate-laws

determine the rate law of the reaction. [15 points]

4 pt i) $\frac{r_2}{r_1} = 1^x\left(\frac{0.15}{0.10}\right)^y = \frac{0.0045}{0.003}$

$1.5^y = 1.5$; $y = 1$

4 ii) $\frac{r_3}{r_1} = \left(\frac{0.15}{0.1}\right)^x 1^y = \frac{0.00675}{0.003} = 2.25$

$1.5^x = 2.25$; $x = \frac{\ln 2.25}{\ln 1.5} = \frac{0.810}{0.405} = 2$

4 iii) rate 1 $= \frac{1}{2}\ 0.003\ \frac{M}{sec} = k\,[0.1\ M]^2[0.1\ M]^1 = k\ 10^{-3}\ M^3$

$k = 0.15\ \frac{1}{M^2 sec}$

3 iv) $rate = 0.15\ \frac{1}{M^2 sec}\ [NO]^2[Cl_2]$

6. Describe, qualitatively, using graphical analysis, the data analysis to determine the rate law of the reaction

Crystal violet + sodium hydroxide → products

that is, how to find the value of the rate constant and exponents in

rate = k $[CV]^x$ $[OH^-]^y$

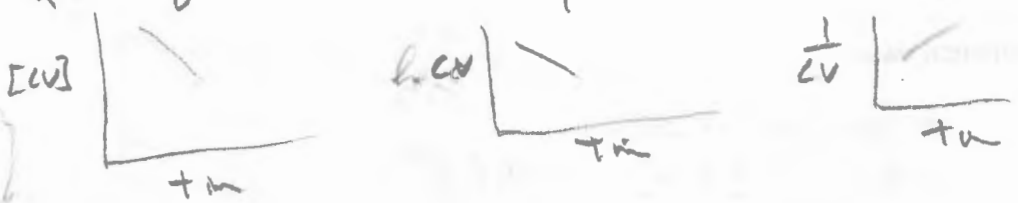
where CV = crystal violet; OH^- = sodium hydroxide.

While need not describe the use of a calibration curve, include any relevant assumptions / experimental conditions in your analysis. [15 points].

i) @ $[OH^-] >> [CV]$

rate = $k^*[CV]^x$; $k^* = k[OH^-]^y$

ii) $x =$ 0 1 2



find x based on which graph matches

3 pts @

iii) $\frac{k^*_{(1)}}{k^*_{(2)}} = \left(\frac{[OH^-]_{(1)}}{[OH^-]_{(2)}}\right)^y$ solve for y

k^* = slope above graph

iv) $k^* = k[OH^-]^y$

solve for k

v) rate = $k[CV]^x[OH^-]^y$

Name: ______________________________ date: ______________ period: ______

ch. 10 & 14 gas & kinetics retest 80 points ~~(5 ec)~~ AP chemistry

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1. In regards to the hypothetical reaction mechanism, [15 points]

1) $E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES1$

2) $ES1 \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} ES2$

3) $ES2 \xrightarrow{k_3} E + P$ (slowest step)

source: https://www.chegg.com/homework-help/questions-and-answers/derive-rate-equation-following-enzyme-reaction-mechanism-es1-es2-may-assume-rapid-equilibr-q34728537

$r = k(E)(S)$; $k = k_3 \frac{k_1}{k_{-1}} \frac{k_2}{k_{-2}}$

a. What is the rate law based on the above reaction mechanism?

1pt i) $r = k_3 [ES2]$ (2)

1pt ii) Rx 2: $r_f = r_b$

$k_2 ES1 = k_{-2} ES2$

$ES2 = \frac{k_2}{k_{-2}} ES1$ (1)

(iii) Rx 1: $r_f = r_b$

1pt $k_1 (E)(S) = k_{-1} ES1$

$ES1 = \frac{k_1}{k_{-1}} (E)(S)$

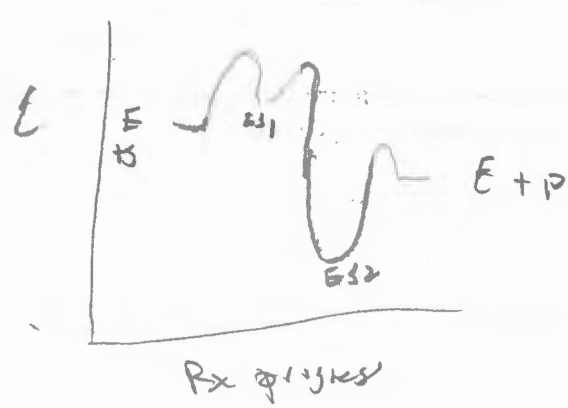
(1) subst (1)

1pt $ES2 = \left[\frac{k_1}{k_{-1}} (E)(S)\right] \frac{k_2}{k_{-2}}$

subst (2)

b. Sketch / label the reaction energy profile of the above reaction mechanism and clearly identify the reactant(s), product(s), and intermediate(s) in the reaction energy profile and assume that the first, second, and third steps in the mechanism is endothermic, exothermic, and endothermic, respectively, while it is an exothermic reaction, overall.

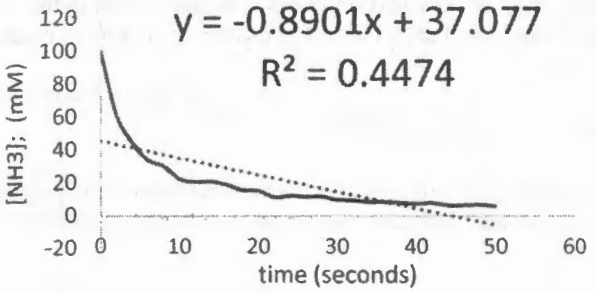
2pt @ = 8pt

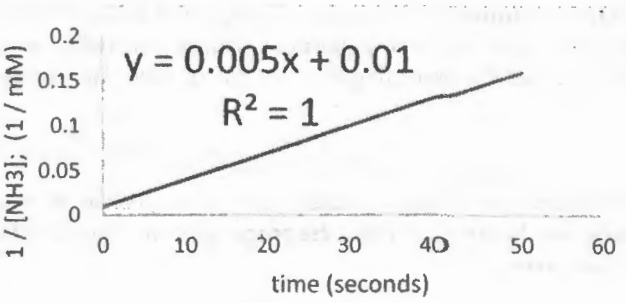


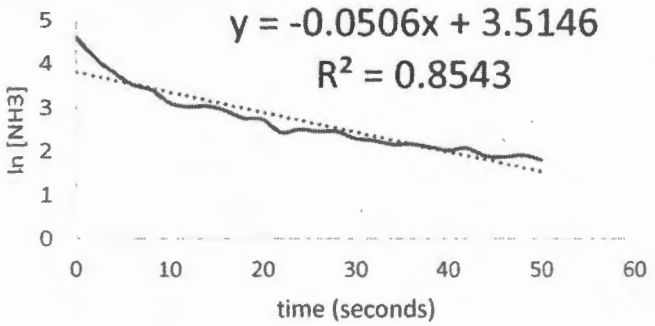
2pt = label

2. In regards to the reaction: $2\ NH_3 \rightarrow 3\ H_2 + N_2$ [~~15~~ 10 points]

a. Based on the below hypothetical graphs,







3

what is the rate law of the reaction ?

rate = $\frac{0.005}{mM\ sec}$ $[NH_3]^2$

3 + 2 pt

b. How much time would it take for 200 mM NH_3 to become 25 mM ?

2 pt

3

$\frac{1}{A} = \frac{1}{A_0} + kt$

$\frac{1}{25\ mM} = \frac{1}{200\ mM} + \frac{0.005}{mM\ sec}\ t$

$0.04 = 0.005 + 0.005\ t$

$0.035 = 0.005\ t$

$t = 7\ sec$

3. A rigid 125 mL container has a pressure of 95 kPa and the temperature in the container is 22 °C; the container is heated to 58 °C; what is the pressure in the container ? [10 points]

$PV = nRT$

$\frac{P_1}{T_1} = \frac{?}{T_2}$

$\frac{95\ kPa}{(22+273)K} = \frac{P}{(58+273)K}$

$P = \frac{95\ (58+273)}{22+273} = 106\ kPa$

(-5

5 pt

$P = \frac{m}{V}\frac{RT}{\text{molar mass}}$ $= \frac{dRT}{\text{molar mass}}$ (5 pt)

$= \frac{714\ \text{mm Hg}}{760\ \text{mm Hg}}\ \frac{1\ \text{atm}}{}\ \frac{8.8\ \text{g}}{\text{mol}}\ \Big/ \left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)(127+273)\ \text{K}$ (2.5 g)

4. In regards to the reaction: $3\ H_{2(g)} + N_{2(g)} \rightarrow 2\ NH_{3(g)}$, the initial partial pressure of N_2 and H_2 is 5.0 atm and 12.0 atm, respectively, in a 125 L container at 137 °C. What is the total pressure in the container at the end of the reaction ? Assume % yield = 100%. [20 points]

i) $n_{N_2} = \frac{P_{N_2}V}{RT} = \frac{5\ \text{atm}\ (125\ \text{L})}{\left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)(137+273)\ \text{K}} = 18.57\ \text{mol}\ N_2$

$n_{H_2} = \frac{P_{H_2}V}{RT} = \frac{12\ \text{atm}\ (125\ \text{L})}{0.0821\ \frac{\text{L atm}}{\text{mol K}}\ (137+273)\ \text{K}} = 44.56\ \text{mol}\ H_2$

ii) $44.56\ \text{mol}\ H_2\ \frac{1\ \text{mol}\ N_2}{3\ \text{mol}\ H_2} = 14.85\ \text{mol}\ H_2$ needed to react with $18.57\ \text{mol}\ N_2$

$\therefore N_2$ is excess → H_2 is limiting

$18.57 - 14.85 = 3.72$ mol N_2 remained (5 pts)

iii) $44.56\ \text{mol}\ H_2\ \frac{2\ \text{mol}\ NH_3}{3\ \text{mol}\ H_2} = 29.7\ \text{mol}\ NH_3$ produced

iv) $P_{total} = \frac{n_{total}RT}{V}$

$= \frac{(n_{NH_3} + n_{N_2} + n_{H_2})RT}{V}$

$= \frac{(29.7 + 3.72 + 0)\ \text{mol}\ \left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)(137+273)\ \text{K}}{125\ \text{L}}$

$= 9.0\ \text{atm}$

rate = $k[H_2]^x [N_2]^y$

5. Based on the below hypothetical experimental value regarding the reaction: $3\ H_{2(g)} + N_{2(g)} \rightarrow 2\ NH_{3(}$

Expt	$[H_2]$; mM	$[N_2]$; mM	$\frac{\Delta [H_2]}{\Delta t}$; $\frac{\mu M}{sec}$
1	1.0	4.0	9.0
2	1.0	4.0	18.0
3	2.0	16.0	72.0

determine the rate law of the reaction, where the units in the rate constant includes mM. [1 5 points]

4pt i) $\frac{r2}{r1} = 4^y \cdot 2$; $y = \frac{1}{2}$

4 ii) $\frac{r3}{r2} = 2^x 4^{\frac{1}{2}} = \frac{72}{18} = 4$; $x = 1$

4 iii) $r1 = \frac{1}{3} \frac{2\mu M}{sec} = k(1mM)(1mM)^{\frac{1}{2}}$

$3 \cdot \frac{\mu M}{sec} \quad \frac{mM}{10^3 \mu M} = k\ 1\ mM^{\frac{1}{2}}$

$k = \frac{3 \cdot 10^{-3}}{mM^{\frac{1}{2}}\ sec}$

3 iv) $rate = \frac{3 \cdot 10^{-3}}{mM^{\frac{1}{2}}\ sec} [H_2]\ [N_2]^{\frac{1}{2}}$

6. old topic: which atom, carbon versus nitrogen, has the larger first ionization energy ? basis / rationale ? [10 points] bl

↑ Z → ↑ Zeff → ↑ F_{att} → harder to remove e- → ↑ energy → ↑ IE

Ref Q