NAME: SECTION:

CHEM 112 - Exam III pg. 2/8

1.) For the mechanism below answer the following questions:

$$2NO \rightleftharpoons N_2O_2$$
$$N_2O_2 + O_2 \rightarrow 2NO_2$$
$$\overline{2NO + O_2 \rightarrow 2NO_2}$$

a.) What is the intermediate of the elementary steps? (Hint: what gets crossed out while adding the chemical equations together) (3 points)

$N_2O_2$

b.) For the second elementary step, $rate_1 = 2.5 \times 10^{-3}[O_2]^y$, what is the value for y? (3 points)

1

c.) If the rate of disappearance of $O_2$ is 7.0 M $s^{-1}$, what is the rate of $NO_2$ appearance? (4 points)

$$-\frac{\delta[O_2]}{\delta t} = \frac{1}{2}\frac{\delta(NO_2)}{\delta t}$$

$$-(-7.0\ M s^{-1}) = \frac{1}{2}\left(\frac{\delta[NO_2]}{\delta t}\right)$$

$$14.0\ M s^{-1} = \frac{\delta[NO_2]}{\delta t}$$

NAME: SECTION:



2.) For the reaction and data below, answer the following quesitons:

$$H_2O + CO_2 \rightarrow H_2CO_3$$

| Exp. | $H_2O$ (M) | Rel. conc. | $CO_2$ (M) | Rel. conc. | Rate ($Ms^{-1}$) | Rate change |
|---|---|---|---|---|---|---|
| 1 | 0.1 | | 0.01 | | $1.5x10^{-3}$ | |
| 2 | 0.1 | | 0.01 | | $1.5x10^{-3}$ | |
| 3 | 0.2 | | 0.01 | | $3.0x10^{-3}$ | |
| 4 | 0.2 | | 0.02 | | $6.0x10^{-3}$ | |

a.) What is the order with respect to $H_2O$? (5 points)

1st

b.) What is the order with respect to $CO_2$? (5 points)

1st

c.) Write the full rate law, with the value for *k*, for the reaction? (5 points)

$rate = k[H_2O]^1[CO_2]^1$

$1.5x10^{-3} = k(0.1)^1(0.01)^1$

$1.5x10^{-6} = k$

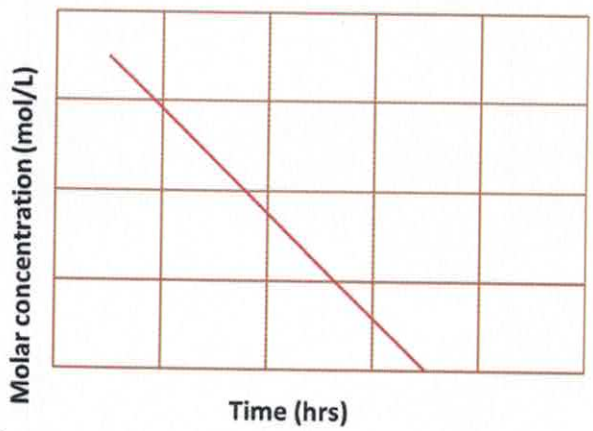
~~$rate = 1.5x10^{-6}$~~

$rate = 1.5x10^{-6}[H_2O]^1[CO_2]^1$

NAME: SECTION:



3.) After a set of experiments in a lab on the reaction R → P, you plot your data and get the plot below:




Use the correct integrated rate equation to determine how long it takes for 0.2 M R to decrease to 20% of its original concentration if the rate constant $k = 7.5\text{x}10^{-3}$ M $s^{-1}$. (15 points)

$[R] = [R]_0 - kt$

$[R]_0 = 0.2\,M$ ↙ 20%

$[R] = (0.2\,M)(0.20) = 0.04$

$0.04\,M = 0.2\,M - 7.5\text{x}10^{-3}\,M\,s^{-1}\,(t)$

$-0.16\,M = -7.5\text{x}10^{-3}\,M\,s^{-1}$

$21.3\,s = t$

NAME: SECTION:

CHEM 112 - Exam III pg. 5/8

4.) For the following reaction, calculate $\Delta G^o$ at 25 °C. (20 pts)

$$2CH_4(g) + 4O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$$

| Substance | $S^o$, J/mol-K | $H^o$, kJ/mol |
|---|---|---|
| $CH_4(g)$ | 186.15 | -74.81 |
| $CO_2(g)$ | 213.63 | -393.51 |
| $H_2O(g)$ | 188.72 | -241.82 |
| $O_2(g)$ | 205.03 | 0 |
| $H_2O(l)$ | 69.91 | -285.83 |

$\Delta G = \Delta H - T\Delta S$

$\Delta H = \sum H_{products} - \sum H_{reactants}$

$\Delta H = \left(2 \cdot -393.51 \frac{kJ}{mol} + 4 \cdot -285.83 \frac{kJ}{mol}\right) - \left(2 \cdot -74.81 \frac{kJ}{mol} + 4 \cdot 0 \frac{kJ}{mol}\right)$

$\Delta H = -1781 \frac{kJ}{mol}$

$\Delta S = \sum S_{products} - \sum S_{reactants}$

$\Delta S = \left(2 \cdot 213.63 \frac{J}{mol \cdot K} + 4 \cdot 69.91 \frac{J}{mol \cdot K}\right) - \left(2 \cdot 186.15 \frac{J}{mol \cdot K} + 4 \cdot 205.03 \frac{J}{mol \cdot K}\right)$

$\Delta S = -485 \frac{J}{mol \cdot K} = -0.485 \frac{kJ}{mol \cdot K}$

$\Delta G = \Delta H - T\Delta S$

$= -1781 \frac{kJ}{mol} - 298K\left(-0.485 \frac{kJ}{mol \cdot K}\right)$

$\Delta G = -1636 \frac{kJ}{mol}$

NAME: SECTION:

CHEM 112 - Exam III pg. 6/8

5.) At equilibrium the following reaction has a $\Delta G^o$ value of -11.9 kJ/mol. You go into the lab and find the reaction NOT at equilibrium and instead find the concentrations are $[NO_2] = 0.025$ M, $[O_3] = 0.0010$ M, $[NO_3] = 0.030$ M, and $[O_2] = 0.10$ M.

$$NO_{2(g)} + O_{3(g)} \rightleftharpoons NO_{3(g)} + O_{2(g)}$$

$$Q = \frac{[O_2][NO_3]}{[NO_2][O_3]}$$

Find $\Delta G$ for the above non-equilibrium reaction at 125 °C (20 points)

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta G = -11.9 \frac{kJ}{mol} + 8.314 \frac{J}{mol \cdot K}(298\,K) \ln \frac{(0.1)(0.03)}{(0.025)(0.001)}$$

$$\Delta G = -11.9 \frac{kJ}{mol} + 11861 \frac{J}{mol}$$

$$\Delta G = -11.9 \frac{kJ}{mol} + 11.86 \frac{kJ}{mol}$$

$$\Delta G = -0.04 \frac{kJ}{mol}$$

NAME: SECTION:



6.) Circle the correct answer: (4 points each)

a.) A reaction has a positive value of $\Delta H^o$, the reaction is:

endothermic spontaneous exothermic

b.) A car engine gives off heat while doing work, therefore the value for q is:

positive negative zero

c.) A reaction has a negative value of $\Delta G^o$, the reaction is:

disordered spontaneous non-spontaneous

d.) For the reaction $CO + 2O_2 \rightarrow CO_2 + O_3$, the disorder, $\Delta S^o$:

increases decreases is zero

e.) A reaction has a positive $\Delta H^o$ and a negative $\Delta S^o$, the reaction is:

spontaneous non-spontaneous make believe