Dr. Zellmer | Chemistry 1220 | All Sections
Time: 7 PM Sun. | Spring Semester 2023 | February 5, 2023
30 min | Quiz III

Name _____ Rec. TA/time _____

Show **ALL** your work or **EXPLAIN** to receive full credit. R = 0.08206 L•atm/mol•K = 8.314 J/mol•K

1. (6 pts) The rate law for the decomposition of AB_2 ($AB_2 \rightarrow AB + \frac{1}{2} B_2$) is

$$r = (0.630\ M^{-1} \bullet s^{-1})\ [AB_2]^2.$$

a) (4 pts) If the initial concentration of AB_2 is 3.00 M what will the **concentration** of AB_2 be (in M) after 1.00 minute?

b) (2 pts) What is the rate after 1.00 minute? Not asked for on the Carmen quiz.

2. (4 pts) The decomposition of AB (AB → A + B) is zero order in AB with a rate constant of 1.10×10^{-3} M•**s**$^{-1}$. If the initial concentration is 0.100 M at the very start of the reaction what is the second half-life (in minutes)?

3. (8 pts) The rate law for the decomposition of N_2O_5 ($N_2O_5 \rightarrow 2\ NO_2 + \frac{1}{2}\ O_2$) at 70°C is

$$r = (6.82 \times 10^{-3}\ s^{-1})\ [N_2O_5]$$

a) (5 pts) If the initial concentration of N_2O_5 is 1.50 M, how **long** (in minutes) will it take for the reaction to reach 90% completion?

b) (3 pts) What is the **half-life** (in min) for the reaction based on the initial concentration of 1.50 M?

4. (3 pts) Explain the main way a catalyst **<u>increases</u>** rate by using the **Arrhenius Equation**. (**Show this equation and use it in your explanation!**)

5. (5 pts) The rate constant for a reaction at 40.0°C is exactly three times that at 20.0°C. Calculate the Arrhenius **energy of activation**, $\mathbf{E_a}$, (in kJ/mol) for the reaction.

6. (3 pts) Which of the following statements is (are) **TRUE**?

1) reaction rates depend on temperature, reactant structure, concentration of reactants and the presence of catalysts

2) catalysts shift reaction equilibria toward the side of the products

3) enzymes are catalysts in living organisms and increase rate by lowering the activation energy, E_a.

4) activation energy is required for both exothermic and endothermic reactions

5) a catalyst never has its concentration appear in the rate law

7. (3 pts) Given the following mechanism, identify which species which may be classified as **intermediate(s)** and which as **catalyst(s)** in the formation of XO_2 from X and O_2 ($X + O_2 \rightarrow XO_2$)?

$$X + YO_2 \rightarrow XO + YO$$
$$XO + YO \rightarrow XO_2 + Y$$
$$Y + O_2 + Z \rightarrow YO + ZO$$
$$YO + ZO \rightarrow YO_2 + Z$$

8. (9 pts) The following mechanism has been proposed for the gas phase reaction between H_2 and CO.

$$H_2 \rightleftarrows 2\,H \qquad \text{(fast, equilibrium)}$$

$$H + CO \rightarrow HCO \qquad \textbf{(slow)}$$

$$H + HCO \rightarrow H_2CO \qquad \text{(fast)}$$

(a) What is the overall reaction?

(b) What is (are) the **intermediate(s)** in the mechanism?

(c) What is the **molecularity** of each of the following elementary steps?

Step 1 Step 2

(d) What is the **rate-determining step** (explain why)?

(e) What is the **rate law** predicted by this mechanism?

9. (9 pts) Consider the following hypothetical reaction and the established rate law. Select an acceptable mechanism.

$A_2 + B_2 \rightarrow X + Y$ rate = k $[A_2]$ $[B_2]/[Y]$ (exp rate law)

a) $A_2 \rightleftarrows 2\,A$ (fast)

$B_2 + A \rightarrow C$ (slow)

$C + A \rightarrow X + Y$ (fast)

b) $A_2 + B_2 \rightleftarrows C$ (fast)

$C \rightarrow X + Y$ (slow)

c) $A_2 \rightleftarrows C + Y$ (fast)

$B_2 + C \rightarrow X$ (slow)

d) $B_2 \rightarrow 2\,B$ (slow)

$B + A_2 \rightarrow C$ (fast)

$C + B \rightarrow X + Y$ (fast)

e) $B_2 \rightleftarrows 2\,B$ (fast)

$B \rightarrow C + Y$ (slow)

$A_2 + C + B \rightarrow X$ (fast)

USEFUL INFORMATION

R = 0.08206 L-atm/mol-K = 8.3145 J/mol-K

$$[A]_t = -kt + [A]_0 \qquad \frac{1}{[A]_t} = kt + \frac{1}{[A]_0} \qquad \ln[A]_t = -kt + \ln[A]_0$$

$$t_{1/2} = \frac{0.693}{k} \qquad t_{1/2} = \frac{1}{k[A]_0} \qquad t_{1/2} = \frac{[A]_0}{2k}$$

$$k = A\, e^{-E_a/RT} \qquad \ln(k) = -(\frac{E_a}{R})\,(\frac{1}{T}) + \ln(A)$$

$$\ln(\frac{k_2}{k_1}) = \frac{E_a}{R}(\frac{1}{T_1} - \frac{1}{T_2}) \qquad \log(\frac{k_2}{k_1}) = \frac{E_a}{2.303R}(\frac{1}{T_1} - \frac{1}{T_2})$$

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1.008 **H** 1																	4.003 **He** 2
2	6.941 **Li** 3	9.012 **Be** 4											10.811 **B** 5	12.011 **C** 6	14.007 **N** 7	15.999 **O** 8	18.998 **F** 9	20.179 **Ne** 10
3	22.990 **Na** 11	24.305 **Mg** 12											26.98 **Al** 13	28.09 **Si** 14	30.974 **P** 15	32.06 **S** 16	35.453 **Cl** 17	39.948 **Ar** 18
4	39.098 **K** 19	40.08 **Ca** 20	44.96 **Sc** 21	47.88 **Ti** 22	50.94 **V** 23	52.00 **Cr** 24	54.94 **Mn** 25	55.85 **Fe** 26	58.93 **Co** 27	58.69 **Ni** 28	63.546 **Cu** 29	65.38 **Zn** 30	69.72 **Ga** 31	72.59 **Ge** 32	74.92 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
5	85.47 **Rb** 37	87.62 **Sr** 38	88.91 **Y** 39	91.22 **Zr** 40	92.91 **Nb** 41	95.94 **Mo** 42	98 **Tc** 43	101.07 **Ru** 44	102.91 **Rh** 45	106.42 **Pd** 46	107.87 **Ag** 47	112.41 **Cd** 48	114.82 **In** 49	118.69 **Sn** 50	121.75 **Sb** 51	127.60 **Te** 52	126.90 **I** 53	131.39 **Xe** 54
6	132.91 **Cs** 55	137.33 **Ba** 56	138.91 **La** 57	178.39 **Hf** 72	180.95 **Ta** 73	183.85 **W** 74	186.21 **Re** 75	190.23 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.97 **Au** 79	200.59 **Hg** 80	204.38 **Tl** 81	207.2 **Pb** 82	208.98 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
7	223 **Fr** 87	226.03 **Ra** 88	227.03 **Ac** 89	261 **Rf** 104	262 **Ha** 105	263 **Sg** 106	262 **Ns** 107	265 **Hs** 108	266 **Mt** 109	269 110	272 111	277 112						

Lanthanide Series	140.12 **Ce** 58	140.91 **Pr** 59	144.24 **Nd** 60	145 **Pm** 61	150.36 **Sm** 62	151.96 **Eu** 63	157.25 **Gd** 64	158.93 **Tb** 65	162.50 **Dy** 66	164.93 **Ho** 67	167.26 **Er** 68	168.93 **Tm** 69	173.04 **Yb** 70	173.04 **Lu** 71
Actinide Series	232.04 **Th** 90	231.04 **Pa** 91	238.03 **U** 92	237.05 **Np** 93	**Pu** 94	**Am** 95	**Cm** 96	**Bk** 97	**Cf** 98	**Es** 99	**Fm** 100	**Md** 101	**No** 102	**Lr** 103

A PERIODIC CHART OF THE ELEMENTS
(Based on ^{12}C)