

Name _____ Rec. TA/time _____

Show **ALL** your work or **EXPLAIN** to receive full credit. $R = 0.08206 \text{ L}\cdot\text{atm/mol}\cdot\text{K} = 8.314 \text{ J/mol}\cdot\text{K}$

1. (6 pts) The rate law for the decomposition of AB_2 ($\text{AB}_2 \rightarrow \text{AB} + \frac{1}{2} \text{B}_2$) is

$$r = (0.630 \text{ M}^{-1}\cdot\text{s}^{-1}) [\text{AB}_2]^2.$$

- 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 ($\text{AB} \rightarrow \text{A} + \text{B}$) is zero order in AB with a rate constant of $1.10 \times 10^{-3} \text{ M}\cdot\text{s}^{-1}$. 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 ($\text{N}_2\text{O}_5 \rightarrow 2 \text{NO}_2 + \frac{1}{2} \text{O}_2$) at 70°C is

$$r = (6.82 \times 10^{-3} \text{ s}^{-1}) [\text{N}_2\text{O}_5]$$

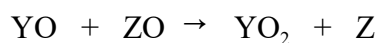
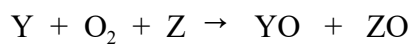
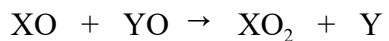
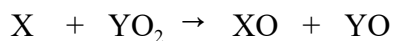
- a) (5 pts) If the initial concentration of N_2O_5 is 1.50 M, how **long** (in minutes) will it take for the reaction to reach 90% completion?

- 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 increases 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**, 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 ($\text{X} + \text{O}_2 \rightarrow \text{XO}_2$)?

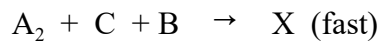
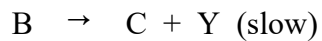
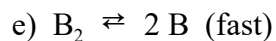
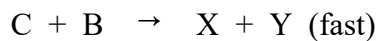
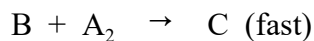
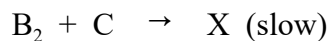
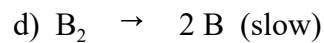
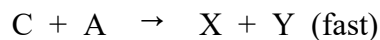
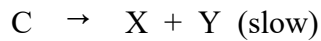
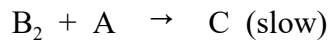
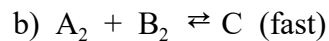
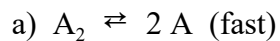
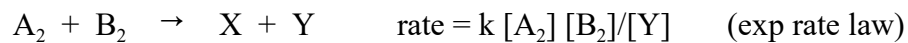


8. (9 pts) The following mechanism has been proposed for the gas phase reaction between H_2 and CO .



- (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?
- | <u>Step 1</u> | <u>Step 2</u> |
|---------------|---------------|
| | |
- (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.



USEFUL INFORMATION

$$R = 0.08206 \text{ L-atm/mol-K} = 8.3145 \text{ J/mol-K}$$

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

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

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

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

| | IA | IIA | IIIB | IVB | VB | VIB | VII | VIII | | | 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 Uu 110 | 272 Uub 111 | 277 Uut 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 ¹²C)