

# Exam 2A

## Chem 1142

### Spring 2017

Name: \_\_\_\_\_

**MULTIPLE CHOICE.** [3 pts ea.] Record the best response on the scantron sheet. [45 pts total.]

Q1. Which version of the exam do you have?

- a) 2A
- b) 2B

Q2. Which of the following expressions is equal to the **rate of reaction** for the following chemical equation?



- a)  $-\frac{1}{2} \Delta[A]/\Delta t$
- b)  $+\Delta[B]/\Delta t$
- c)  $3\Delta[C]/\Delta t$
- d)  $-\Delta[D]/\Delta t$

Q3. For the overall stoichiometric equation:  $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ , the rate law can be written as:

- a)  $rate = k[N_2][H_2]$
- b)  $rate = k[N_2][H_2]^3$
- c)  $rate = k[N_2][H_2]^2/[NH_3]^2$
- d) impossible to say for sure
- e) zeroth order with respect to nitrogen

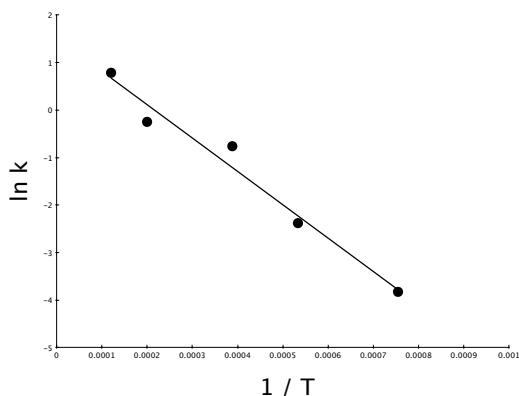
Q4. The units of a rate constant for a second order overall reaction are:

- a) M/s
- b)  $s^{-1}$
- c)  $M^{-1}cm^{-1}$
- d)  $M^{-1}s^{-1}$
- e)  $M^2$

Q5. The rate constant for a reaction with the rate law:  $rate = k[A]$ , is found to have a value of  $0.012 s^{-1}$  at a temperature of  $17^\circ C$ . How long will it take for the concentration of A to change from 1.2 M to 0.60 M?

- a) 58 s
- b) 50. s
- c)  $1.0 \times 10^2 s$
- d) 83 s
- e) 85 s

Q6. What information can be determined from the following type of graph:



- a) The activation energy of the reaction  
 b) Whether the reaction is zeroth order  
 c) Whether the reaction is first order  
 d) Whether the reaction is second order  
 e) Whether the reaction is an elementary reaction
- Q7. The half-life for a first order reaction is 15 s. What fraction of **reactants** will remain after 30. s have passed?  
 a) 75 %  
 b) 50 %  
 c) 25 %  
 d) 0 %  
 e) Not enough information to determine
- Q8. What type of plot can be used to determine whether a reaction involving a reactant, A, is second order?  
 a)  $\ln k$  vs.  $1 / T$   
 b)  $[A]$  vs  $t$   
 c)  $\ln [A]$  vs.  $t$   
 d)  $1 / [A]$  vs.  $t$   
 e)  $k$  vs.  $t$
- Q9. A reaction is thought to proceed via a mechanism:



the reaction's **rate law** will be given by the expression:

- a)  $rate = k_1[A][B]$   
 b)  $rate = k_1[C]/[A][B]$   
 c)  $rate = k_2[B][C]$   
 d)  $rate = k_2[D]/[C][B]$   
 e)  $rate = k_2[A][B]^2[C]$
- Q10. A chemical reaction has an equilibrium constant of 4,000 at 25 °C. This means that at equilibrium:  
 a) There will mainly be reactants present  
 b) There will mainly be products present  
 c) There will be similar amounts of reactants and products

Q11. Which of the following chemical equations will have the same value for both  $K_c$  and  $K_p$

- a)  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
- b)  $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$
- c)  $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}(\text{g})$
- d)  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
- e)  $2\text{BH}_3(\text{g}) \rightleftharpoons \text{B}_2\text{H}_6(\text{g})$

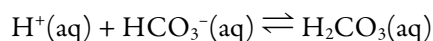
Q12. A chemical equilibrium:  $\text{A} \rightleftharpoons \text{B}$  has an equilibrium constant of 12.4 at 25 °C. If we re-write the chemical equilibrium as:  $2\text{B} \rightleftharpoons 2\text{A}$ , what will the equilibrium constant for this chemical equilibrium become?

- a) 12.4
- b) 6.2
- c)  $2.48 \times 10^2$
- d)  $6.5 \times 10^{-3}$
- e)  $4.0 \times 10^{-2}$

Q13. A chemical equilibrium has a reaction quotient of 34 and an equilibrium constant of 24. This information tells us that:

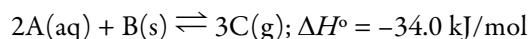
- a) The reaction is already at equilibrium
- b) The reaction will form more products
- c) The reaction will form more reactants
- d) Unable to tell anything from this information
- e) The reaction will reach equilibrium in 10. s

Q14. A small amount of NaOH is added to the following equilibrium, resulting in neutralization of some of the  $\text{H}^+$  ions. How will this affect the position of equilibrium?



- a) No affect
- b) There will be a shift to the left-hand-side (LHS)
- c) There will be a shift to the right-hand-side (RHS)
- d) There will be an increase in the value of the equilibrium constant
- e) There will be a decrease in the value of the equilibrium constant

Q15. Consider the following chemical equilibrium:



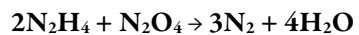
What will happen if the temperature of the equilibrium is raised?

- a) No affect
- b) The equilibrium constant will increase
- c) The equilibrium constant will decrease

### Short Response.

Show ALL work to receive credit.

Q16. [11 pts.] The chemical reaction between hydrazine and dinitrogen tetroxide was initially investigated for travel to the moon in the 1960s. The chemical equation for this reaction is given below:



a) Write out four expressions for the reaction rate (not the rate law!) below:

|      |     |
|------|-----|
| i)   | ii) |
| iii) | iv) |

b) If a set of three experiments was carried out measuring how the initial rate depended upon the initial concentration of each reactant, determine the rate law for this reaction. As part of your answer determine the value of the rate constant,  $k$ . SHOW ALL WORK.

| Experiment # | $[\text{N}_2\text{H}_4]_0 / \text{M}$ | $[\text{N}_2\text{O}_4]_0 / \text{M}$ | Initial rate / $\text{M}\cdot\text{s}^{-1}$ |
|--------------|---------------------------------------|---------------------------------------|---|
| 1            | 0.010                                 | 0.010                                 | 1.80  |
| 2            | 0.020                                 | 0.010                                 | 3.60  |
| 3            | 0.010                                 | 0.025                                 | 11.25                                       |

Q17. [11 pts.] The following chemical equation:



has a rate law of:

$$\text{rate} = k[A]^2$$

with a rate constant equal to  $0.098 \text{ M}^{-1}\cdot\text{s}^{-1}$  at 310 K.

a) What is the half-life for this reaction? The initial concentration of A is 2.0 M.

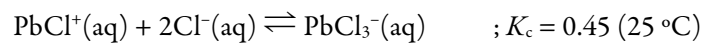
b) How long will it take for the concentration of A to change from 2.0 M to 0.25 M?

c) If you measured how the concentration of A varied with time, what kind of plot would be expected to give a straight line?

Q18. [11 pts.] a) Sketch the potential energy vs. reaction coordinate diagram for an endothermic reaction. Label the axes and carefully indicate on your graph the following pieces of information:  $\Delta H$ , the activation energy, the transition state, reactants, and products.

b) The rate constant for this reaction doubles as the temperature changes from 29 °C to 36 °C. What is the activation energy of the reaction?

Q19. [11 pts.] Given the chemical equilibrium:



a) Write out the expression for the equilibrium constant,  $K_c$ :

b) Show how to, and then calculate the reaction quotient if the initial concentrations are:

$$[\text{PbCl}^+]_0 = 0.10 \text{ M}, [\text{Cl}^-]_0 = 1.5 \text{ M}, [\text{PbCl}_3^-]_0 = 0.20 \text{ M}$$

c) What will happen to the value of the reaction quotient as time passes?

d) Will the concentration of chloride ion increase, decrease, or stay the same over time? Explain.

Q20. [11 pts.] 0.25 moles of Cl<sub>2</sub>, H<sub>2</sub>, and HCl are introduced into a 5.0-L flask. Given the chemical equation:



Calculate the equilibrium concentrations of Cl<sub>2</sub>, H<sub>2</sub>, and HCl. Be sure to show **all** work.

**BONUS Question:**

What is the name given to the molecularity of an elementary reaction where the following number of molecules collide?

**one** = \_\_\_\_\_;      **two** = \_\_\_\_\_;

**three** = \_\_\_\_\_.



## Periodic Table of the Elements

| IA                 | IIA                 |                    |                    |                    |                    |                   |                    |                    |                    |                    | IIIA               | IVA                | VA                 | VIA                  | VIIA               | VIIIA              |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |
|--------------------|---------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|----------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|
| 1<br>H<br>1.01     |                     |                    |                    |                    |                    |                   |                    |                    |                    |                    |                    |                    |                    |                      |                    |                    | 2<br>He<br>4.00    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |
| 3<br>Li<br>6.94    | 4<br>Be<br>9.01     |                    |                    |                    |                    |                   |                    |                    |                    |                    |                    | 5<br>B<br>10.81    | 6<br>C<br>12.01    | 7<br>N<br>14.01      | 8<br>O<br>16.00    | 9<br>F<br>19.00    | 10<br>Ne<br>20.18  |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |
| 11<br>Na<br>22.99  | 12<br>Mg<br>24.31   | 3                  | 4                  | 5                  | 6                  | 7                 | 8                  | 9                  | 10                 | 11                 | 12                 | 13<br>Al<br>26.98  | 14<br>Si<br>28.09  | 15<br>P<br>30.97     | 16<br>S<br>32.07   | 17<br>Cl<br>35.45  | 18<br>Ar<br>39.95  |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |
| 19<br>K<br>39.10   | 20<br>Ca<br>40.08   | 21<br>Sc<br>44.96  | 22<br>Ti<br>47.87  | 23<br>V<br>50.94   | 24<br>Cr<br>52.00  | 25<br>Mn<br>54.94 | 26<br>Fe<br>55.85  | 27<br>Co<br>58.93  | 28<br>Ni<br>58.69  | 29<br>Cu<br>63.55  | 30<br>Zn<br>65.39  | 31<br>Ga<br>69.72  | 32<br>Ge<br>72.61  | 33<br>As<br>74.92160 | 34<br>Se<br>78.96  | 35<br>Br<br>79.90  | 36<br>Kr<br>83.80  |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |
| 37<br>Rb<br>85.47  | 38<br>Sr<br>87.62   | 39<br>Y<br>88.91   | 40<br>Zr<br>91.22  | 41<br>Nb<br>92.91  | 42<br>Mo<br>95.94  | 43<br>Tc<br>[98]  | 44<br>Ru<br>101.07 | 45<br>Rh<br>102.91 | 46<br>Pd<br>106.42 | 47<br>Ag<br>107.87 | 48<br>Cd<br>112.41 | 49<br>In<br>114.82 | 50<br>Sn<br>118.71 | 51<br>Sb<br>121.76   | 52<br>Te<br>127.60 | 53<br>I<br>126.90  | 54<br>Xe<br>131.29 |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |
| 55<br>Cs<br>132.91 | 56<br>Ba*<br>137.33 | 57<br>La<br>138.91 | 58<br>Ce<br>140.12 | 59<br>Pr<br>140.91 | 60<br>Nd<br>144.24 | 61<br>Pm<br>[145] | 62<br>Sm<br>150.36 | 63<br>Eu<br>151.96 | 64<br>Gd<br>157.25 | 65<br>Tb<br>158.93 | 66<br>Dy<br>162.50 | 67<br>Ho<br>164.93 | 68<br>Er<br>167.26 | 69<br>Tm<br>168.93   | 70<br>Yb<br>173.04 | 71<br>Lu<br>174.97 | 72<br>Hf<br>178.49 | 73<br>Ta<br>180.95 | 74<br>W<br>183.84  | 75<br>Re<br>186.21 | 76<br>Os<br>190.23 | 77<br>Ir<br>192.22 | 78<br>Pt<br>195.08 | 79<br>Au<br>196.97 | 80<br>Hg<br>200.59 | 81<br>Tl<br>204.38 | 82<br>Pb<br>207.20 | 83<br>Bi<br>208.98 | 84<br>Po<br>[210] | 85<br>At<br>[210] | 86<br>Rn<br>[222] |
| 87<br>Fr<br>[223]  | 88<br>Ra**<br>[226] | 89<br>Ac<br>[227]  | 90<br>Th<br>232.04 | 91<br>Pa<br>231.04 | 92<br>U<br>238.03  | 93<br>Np<br>[237] | 94<br>Pu<br>[244]  | 95<br>Am<br>[243]  | 96<br>Cm<br>[247]  | 97<br>Bk<br>[247]  | 98<br>Cf<br>[251]  | 99<br>Es<br>[252]  | 100<br>Fm<br>[257] | 101<br>Md<br>[258]   | 102<br>No<br>[259] | 103<br>Lr<br>[262] | 104<br>Rf<br>[261] | 105<br>Db<br>[262] | 106<br>Sg<br>[266] | 107<br>Bh<br>[264] | 108<br>Hs<br>[265] | 109<br>Mt<br>[268] | 110<br>[269]       | 111<br>[272]       | 112<br>[277]       | 113                | 114                | 115                | 116               | 117               | 118<br>[293]      |

$$R = 8.3145 \frac{\text{J}}{\text{mol} \cdot \text{K}} = 0.08206 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}}$$

$$k = A e^{-\frac{E_A}{RT}}$$

$$\ln k = -\frac{E_A}{R} \cdot \frac{1}{T} + \ln A$$

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

• 0-order:  $[A]_t = -kt + [A]_0$

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

• 1-order:  $\ln[A]_t = -kt + \ln[A]_0$   $\ln \left( \frac{[A]_t}{[A]_0} \right) = -kt$

$$t_{1/2} = \frac{0.693}{k}$$

• 2-order:  $\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$

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

$$K_p = K_c (RT)^{\Delta n_g}$$

Given:  $ax^2 + bx + c = 0$ , then  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$