Chemistry 112-2018 Name: Answer Key

Exam #2, Section 1

1. For a reaction to actually occur, it must be favored by:

a. thermodynamics
c. either thermodynamics or kinetics
b. kinetics
d. both thermodynamics and kinetics

2. a) Is the salt $MgSO_4$ more soluble in water at 5 °C or at 35 °C?

a) more soluble

b) less soluble

c) more information is needed, and that information is: $\Delta H_{solution}$

b) Describe the states of CO_2 solubility for a bottle of Diet Coke:

i) before it is open: saturated unsaturated supersaturated

ii) just after opening: saturated unsaturated supersaturated

iii) after going "flat": saturated unsaturated supersaturated

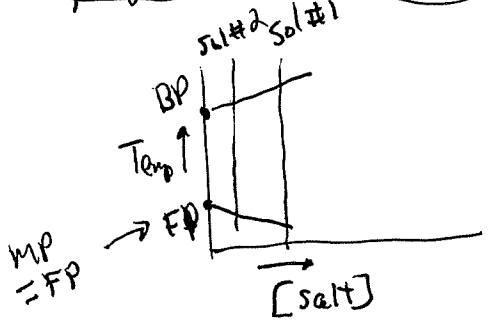
in which state is the solubility of CO_2 greater: before opening or after opening

3. Of the following compounds, which are expected to be highly soluble in water? Circle all that apply.

CF_4 CH_3OH SH_2 CH_3CH_3

4. You have two salt solutions. Solution #1 has a higher boiling point than Solution #2. Which has the higher melting point?

a) Solution #1 b) Solution #2 c) You need to know the salt concentrations to answer this



5. Soap is composed of surfactant molecules. Surfactant molecules are:

a) hydrophilic b) hydrophobic c) both hydrophilic and hydrophobic

6. What is the primary reason water and oil do not mix?

a) if they did, many strong hydrogen bonds would need to be broken

b) in order to do so, the water would need to first be vaporized, which requires too much energy

c) if they did, the ~~entropy of water would~~ decrease markedly

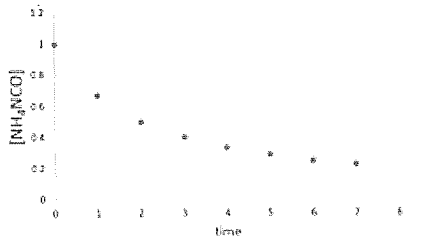
d) the intermolecular forces between the nonpolar molecules are too strong

7. As salt is added to water:

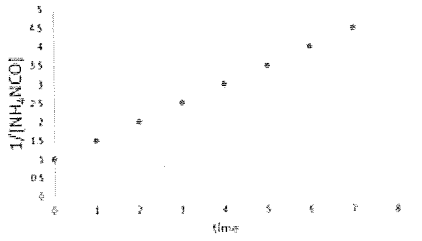
freezing point	a) increases	b) decreases	c) does not change
vapor pressure	a) increases	b) decreases	c) does not change
osmotic pressure	a) increases	b) decreases	c) does not change
boiling point	a) increases	b) decreases	c) does not change

8. The reaction $NH_4NCO \rightarrow (NH_2)_2CO$ was performed and data obtained for the concentration of NH_4NCO over time. The following plots were made from the data.

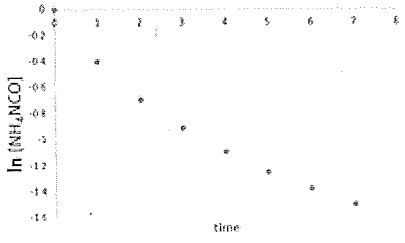
0-order



2nd



1st



What is the order of the reaction with respect to NH_4NCO?

a. zero order b. first order c. second order d. cannot be determined from the plots alone

9. Write the equilibrium constant expression for each reaction:

$P_4(g) + 6\ Cl_2(g) \rightleftarrows 4\ PCl_3(g)$ $\quad K = \dfrac{[PCl_3]^4}{[P_4][Cl_2]^6}$

$NH_3(g) + H_2S(g) \rightleftarrows NH_4HS(s)$ $\quad K = \dfrac{1}{[NH_3][H_2S]}$

NH_4HS is a solid.

10. The equilibrium $2\ SO_2Cl_2(g) \rightleftarrows 2\ SO_2(g) + 2\ Cl_2(g)$ has an equilibrium constant of K = 22.6. What is the value of K for the equilibrium written as: $SO_2(g) + Cl_2(g) \rightleftarrows SO_2Cl_2(g)$?

(a) 22.6 (b) 0.0442 (c) 511 (d) 0.00196 (e) 0.210

reverse + divide by 2.

$K_2 = \dfrac{1}{\sqrt{K_1}}$

11. Two mechanisms are proposed for the reaction,

$(CH_3)_2C{=}CH_2 + H_2O \rightarrow (CH_3)_3COH$

Mechanism A: Step 1. $(CH_3)_2C{=}CH_2 + H_2O \rightarrow (CH_3)_3COH$

✗ Rate = $k_1[(CH_3)_2C{=}CH_2][H_2O]$

Mechanism B: Step 1. $(CH_3)_2C{=}CH_2 + H^+ \rightarrow (CH_3)_3C^+$ (slow)

✓ Step 2. $(CH_3)_3C^+ + H_2O \rightarrow (CH_3)_3COH + H^+$ (fast)

Rate = $k[(CH_3)_2C{=}CH_2][H^+]$

The experimentally determined rate law is: Rate = $k[(CH_3)C{=}CH_2][H^+]$

Which mechanism is supported by the experimental evidence?

a. Mechanism A b. Mechanism B c. neither mechanism d. both mechanisms

12. The following reaction is 2nd–order in NO_2 in and zero–order in CO. Write the rate law for the reaction.

$NO_2 + CO \longrightarrow NO + CO_2$ $\quad$ Rate = $k[NO_2]^2$

13. Initial rate data was found for the following reaction:

$$2\ UO_2^{+} + 4\ H^{+} \longrightarrow U^{4+} + UO_2^{2+} + 2\ H_2O$$

Experiment	$[UO_2^{+}]_0$, M	$[H^{+}]_0$, M	Initial Rate, Ms^{-1}
1	2.85E-3	0.452	5.29
2	5.70E-3	0.452	21.1
3	2.85E-3	0.904	10.6
4	5.70E-3	0.904	42.3

1st order for $[H^+]$

2nd order in $[UO_2^+]$

What is the rate law for the reaction?

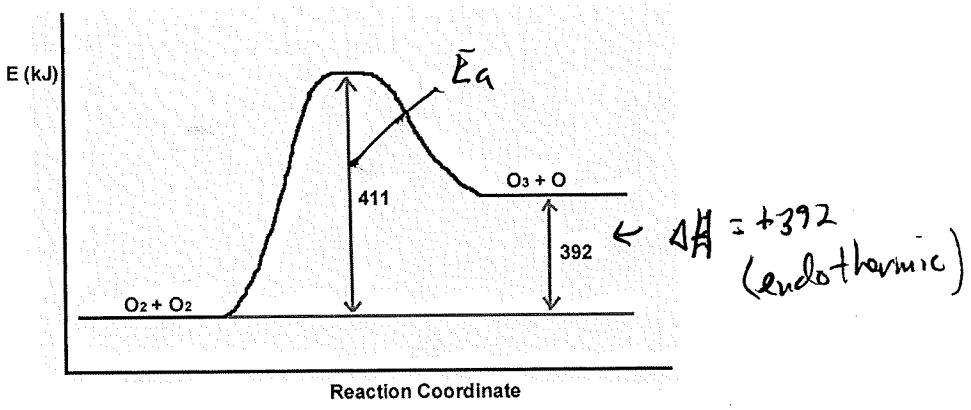
a. rate = $k[UO_2^{+}][H^{+}]$

c. rate = $k[UO_2^{+}]^2[H^{+}]$

b. rate = $k[UO_2^{+}]^2[H^{+}]^4$

d. rate = $k[UO_2^{+}][H^{+}]/[U^{4+}][\ UO_2^{2+}]$

14. Using the reaction coordinate diagram below, determine the activation energy and type of enthalpy change for the reaction.



$\Delta H = +392$ (endothermic)

a. E_a = 392 kJ, endothermic

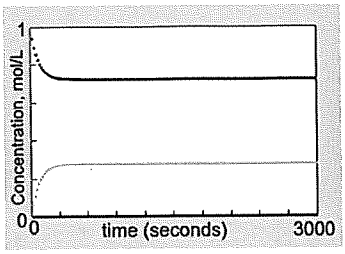
c. E_a = 411 kJ, endothermic

b. E_a = 392 kJ, exothermic

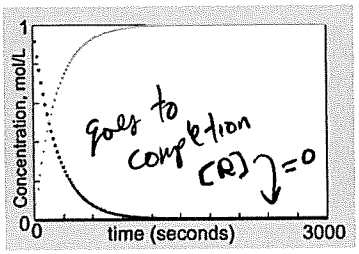
d. E_a = 411 kJ, exothermic

15. *Use the following concentration-time plots. The black line represents reactants and the light gray line represents products. Answer with the correct letter.*

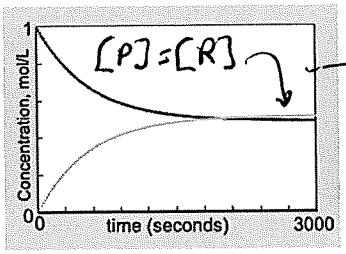
most reactant favored



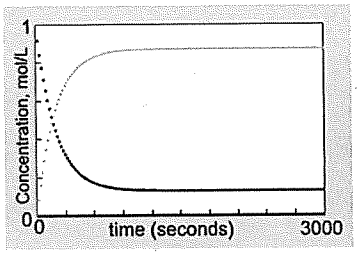
a.



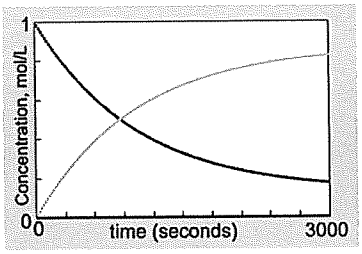
b.



c.



d.



e.

Which reaction goes to completion? Choose the letter: B

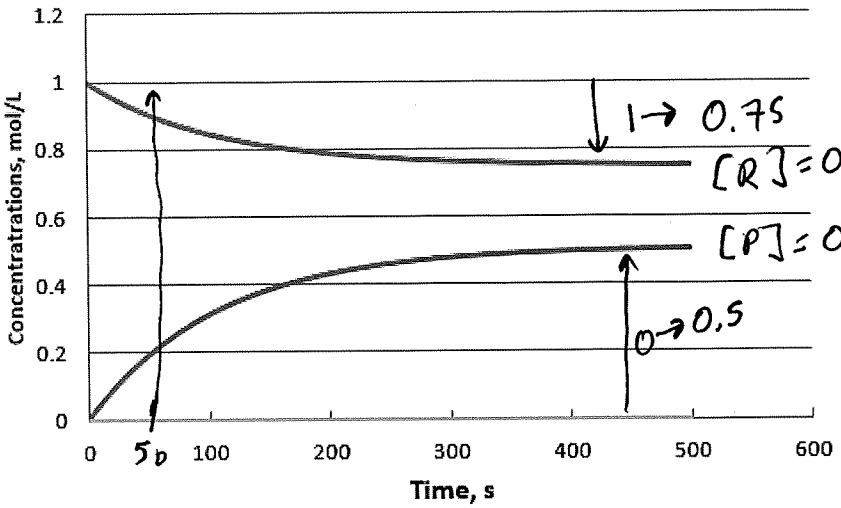
Which reaction has the smallest equilibrium constant? Choose the letter: A

Which reaction has an equilibrium constant close to 1.0? Choose the letter: C

Which of the reactions are product-favored? List all: B, D, E (C is ok)

Which of the reactions are reactant-favored? List all: A

16. The plot below shows a concentration-time curves for a reaction. We'll call the reactant "R" and the product "P".



ΔP is 2x ΔR

a. What is the stoichiometry of the reaction?

i. R ⇌ P

ii. 2 R ⇌ P

iii. R ⇌ 2 P

iv. 2 R ⇌ 3 P

b. At time = 50 seconds, which is/are true? Choose all that apply. Reaction still moving in forward direction

✗ i. the reaction is at equilibrium

✗ ii. the rate of the forward reaction equals the rate of the reverse reaction

iii. the rate of the forward reaction is greater than the rate of the reverse reaction

✗ iv. the rate of the reverse reaction is greater than the rate of the forward reaction

v. the concentration of the reactant is greater than the concentration of product

c. At time = 500 seconds, which is/are true? Choose all that apply. at equilibrium

i. the reaction is at equilibrium

ii. the rate of the forward reaction equals the rate of the reverse reaction

✗ iii. the rate of the forward reaction is greater than the rate of the reverse reaction

✗ iv. the rate of the reverse reaction is greater than the rate of the forward reaction

v. the concentration of the reactant is greater than the concentration of product

d. What is the approximate value of the equilibrium constant? 0.33

$$K = \frac{[P]^2}{[R]} = \frac{(0.5)^2}{(0.75)} = 0.33$$

17. The following mechanism is proposed for a reaction:

Step 1: $NO_2Cl \rightarrow NO_2 + Cl$

Step 2: $Cl + NO_2Cl \rightarrow NO_2 + Cl_2$

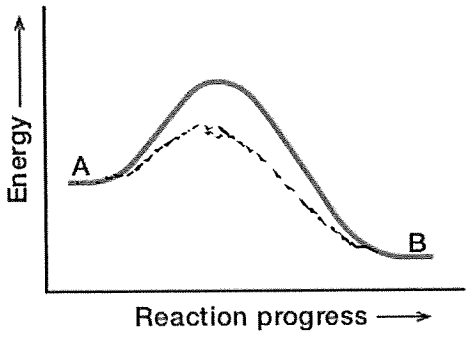
Write the overall reaction: $2\,NO_2Cl \rightarrow 2\,NO_2 + Cl_2$

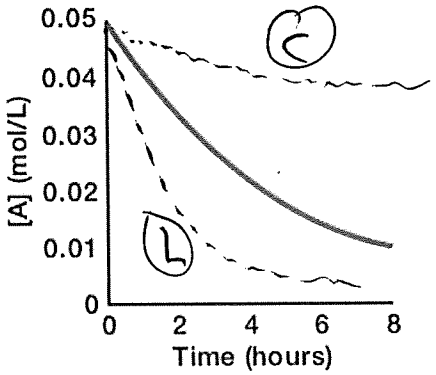
What is the molecularity of Step 2: Bimolecular

Give formulas of intermediates (if none, enter "none): Cl

Give formulas of catalysts (if none, enter "none): none

18. The reaction coordinate diagram for a reaction and its concentration-time curve are shown for the reaction run at 25 °C.





a. draw a curve on the left plot that has a lower activation energy.

b. draw a curve on the right plot for the reaction run if the activation energy were lower. Label it **L**.

c. draw a curve on the right plot for the reaction run at lower temperature. Label it **C**.

d. If the energy of the products (**B** in the left plot) were lower, the reaction rate would be:

faster slower (the same)

Long Answer Questions: Show Your Work

19. A reaction has the following measured rate constants at two temperatures.

$k = 22.0\ s^{-1}$ at 270 K
$k = 54.0\ s^{-1}$ at 300 K

What is the activation energy?

$$\ln \frac{54.0\ s^{-1}}{22.0\ s^{-1}} = -\frac{E_a}{8.314\ \frac{J}{K \cdot mol}} \left[\frac{1}{300K} - \frac{1}{270K}\right]$$

$$0.8979 = -\frac{E_a}{8.314\ \frac{J}{K \cdot mol}} \left(-3.704 \times 10^{-4}\ K^{-1}\right)$$

$$E_a = \frac{0.8979 \times 8.314}{3.704 \times 10^{-4}}\ J/mol$$

$$= 20{,}200\ J/mol$$

$E_a =$ 20.2 kJ/mol

20. Consider the system, $2\ CH_2Cl_2(g) \rightleftarrows CH_4(g) + CCl_4(g)$, which has an equilibrium constant of K = 2.4. If a system has:

$[CH_2Cl_2] = 0.22$ M
$[CH_4] = 1.64$ M
$[CCl_4] = 0.58$ M

$$Q = \frac{[CH_4][CCl_4]}{[CH_2Cl_2]^2} = \frac{(1.64)(0.58)}{(0.22)^2} = 19.7$$

$Q > K$ so reaction proceeds in reverse direction form more reactants (CH_2Cl_2)

What is the value of Q? 19.7

Then choose what will happen:

(a) the system is at equilibrium
(b) the system is not at equilibrium and will react to form more CH_2Cl_2
(c) the system is not at equilibrium and will react to form more CH_4 and CCl_4

21. The half-life of U-238 is 4.5×10^9 years. When U-238 decays it undergoes a series of reactions to form Pb-207.

$$^{238}U \rightarrow \rightarrow \rightarrow {}^{207}Pb$$

If a rock is found that contains 0.384 g U-238 and 0.122 g Pb-207. If we assume that all the Pb-207 originated by decay of the uranium, how old is the rock?

You can assume the molar masses of the isotopes equal their mass numbers.

all radioactive decay reactions are 1st order

$$\ln \frac{N_t}{N_0} = -kt$$

$$k = \frac{0.693}{4.5\times10^9\ y} = 1.54\times10^{-10}\ y^{-1}$$

$$N_t = 0.384\ g\ U\text{-}238 \times \frac{1\ mol\ U}{238\ g} = 0.00161\ mol\ U\text{-}238\ present\ now$$

How much U-238 was there originally? N_0 = mol U-238 now + mol Pb-207 now

$$0.122\ g\ Pb\text{-}207 \times \frac{1\ mol\ Pb}{207\ g} = 0.000589\ mol\ Pb\text{-}207 = 0.000589\ mol\ U\text{-}238\ that\ decayed$$

So: $N_0 = 0.00161\ mol + 0.000589\ mol = 0.00220\ mol\ U\text{-}238$

$$\ln \frac{0.00161\ mol}{0.00220\ mol} = -kt$$

$$-0.312 = -(1.54\times10^{-10}\ y^{-1})t$$

$$t = 2.03\times10^9\ y$$

age = 2.03×10^9 years