Chem 112 – 2020 Section 1 Vining

Practice Exam #2

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

a. thermodynamics
b. kinetics
c. either thermodynamics or 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: _____

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

iv) 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. Soap is composed of surfactant molecules. Surfactant molecules are:

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

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

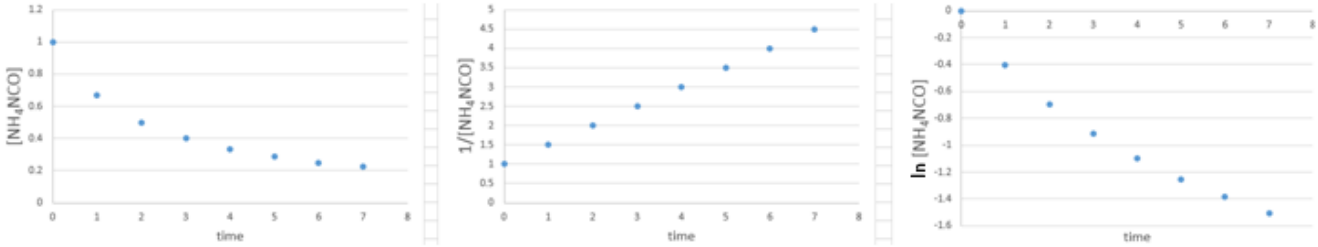
a) if they did, many strong hydrogen bonds would need to be broken

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

6. 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.



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

7. Write the equilibrium constant expression for each reaction:

$$P_4(g) + 6\ Cl_2(g) \rightleftarrows 4\ PCl_3(g)$$

$$NH_3(g) + H_2S(g) \rightleftarrows NH_4HS(s)$$

8. 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

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

$NO_2 + CO \longrightarrow NO + CO_2$ Rate = _____

10. Two mechanisms are proposed for the reaction,

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

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

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)

The experimentally determined rate law is: Rate = $k[(CH_3)_2C=CH_2][H^+]$

Which mechanism is supported by the experimental evidence?

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

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

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

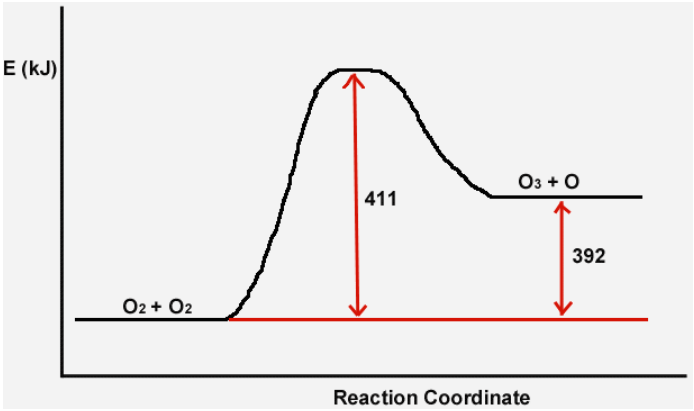
Experiment	$[UO_2^+]_0$, M	$[H^+]_0$, M	Initial Rate, Ms^{-1}
1	**2.85E-3**	**0.452**	5.29
2	**5.70E-3**	**0.452**	21.1
3	**2.85E-3**	**0.904**	10.6
4	**5.70E-3**	**0.904**	42.3

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

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



a. E_a = 392 kJ, endothermic

b. E_a = 392 kJ, exothermic

c. E_a = 411 kJ, endothermic

d. E_a = 411 kJ, exothermic

13. The following mechanism is proposed for a reaction:

Step 1: $NO_2Cl \rightarrow NO_2 + Cl$

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

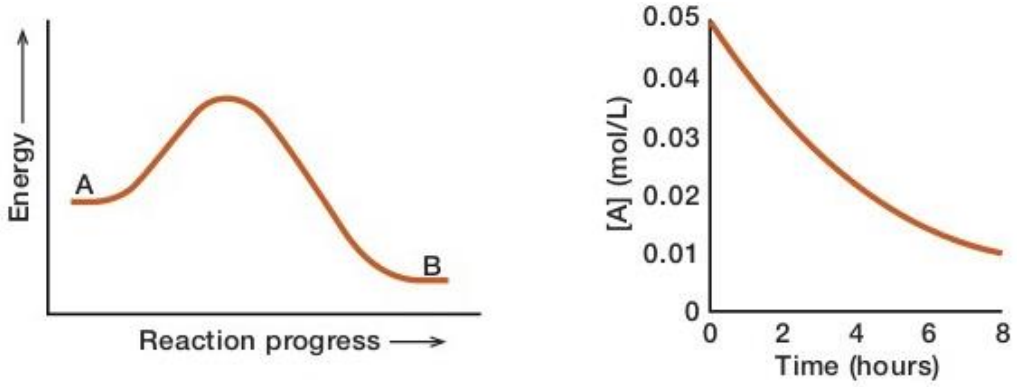
Write the overall reaction: _____

What is the molecularity of Step 2: _____

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

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

14. 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

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

What is the activation energy?

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

E_a = _____ kJ

16. 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

What is the value of Q? _____

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

17. 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.

age = _____ years

18. What is the conjugate base of $H_2PO_4^-$?

(a) H_3PO_4 (b) HPO_4^{2-} (c) $2\ HPO_2$ (d) PO_4^{3-}

19. Write the formulas of common strong acids:

Write the formulas of common strong bases:

20. Calculate the following for a solution that has a pH of 4.68?

$[H_3O^+]$ = _____ mol/L

$[OH^-]$ = _____ mol/L

pOH = _____

21. What is the pH of a 0.00248 M solution of $Ba(OH)_2$?

What is the pH of a 4.8×10^{-4} M solution of HNO_3?

What is the pH of a 3.0 M solution of HCl?

Equations and Constants

$$[\mathrm{A}]_t = [\mathrm{A}]_0 - kt \qquad t_{1/2} = \frac{[\mathrm{A}]_0}{2k}$$

$$\ln\frac{[\mathrm{A}]_t}{[\mathrm{A}]_0} = -kt \qquad t_{1/2} = \frac{0.693}{k}$$

$[\mathrm{A}]_t = [\mathrm{A}]_0 e^{-kt}$

$$\frac{1}{[\mathrm{A}]_t} = \frac{1}{[\mathrm{A}]_0} + kt \qquad t_{1/2} = \frac{1}{k[\mathrm{A}]_0}$$

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

$k = Ae^{-E_a/RT}$ R = 8.314 J/K·mol

pH = -log[H_3O^+]

[H_3O^+] = 10^{-pH}

pOH = -log[OH^-]

[OH^-] = 10^{-pOH}

K_w = 1.0 x 10^{-14} at 25 °C

$$K_\mathrm{p} = K_\mathrm{c}(RT)^{\Delta n}$$

$$\ln\left(\frac{K_2}{K_1}\right) = -\frac{\Delta H^\circ}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$K = \frac{[\mathrm{C}]^c[\mathrm{D}]^d}{[\mathrm{A}]^a[\mathrm{B}]^b}$$

$$K_\mathrm{p} = K_\mathrm{c}(RT)^{\Delta n}$$

When an equilibrium equation is multiplied by a constant, n,

$$K_\mathrm{new} = (K_\mathrm{old})^n$$

When an equilibrium equation is written in the reverse direction,

$$K_\mathrm{new} = \frac{1}{K_\mathrm{old}}$$

When two equations representing equilibrium systems are added together,

$$K_\mathrm{new} = K_1 \times K_2$$

$$Q = \frac{[\mathrm{C}]^c[\mathrm{D}]^d}{[\mathrm{A}]^a[\mathrm{B}]^b}$$