Name KEY

CH302H **EXAM 3** Spring 2013

Multiple Choice Neatly write your choice in the blank provided. (3 pts each)

A **1.** You have 100 mL of a 0.2 M KOH solution to which you add 1 g of $Al(OH)_3$ ($K_{sp} = 3.75 \times 10^{-15}$). Ignoring the volume change that occurs from the addition of the solid, what is the concentration of Al^{3+} ions in the solution?

(a) 4.69×10^{-13} M (b) 1.88×10^{-14} M (c) 1.55×10^{-5} M (d) 5.04×10^{-13} M

B **2.** The solubility of most compounds increases when the temperature is raised because,

(a) for most compounds the dissolution reaction is exothermic.

(b) for most compounds the dissolution reaction is endothermic.

(c) for most compounds the ΔG for the dissolution is negative.

(d) for most compounds the forces holding the solid together are very small.

(e) an increase in the kinetic energy of the water molecules speeds up the reaction.

D **3.** An apple kept at 0°C becomes rotten in 8.3 days. The same apple rots in 10.6 hours at 30°C. Assuming the kinetics of the microorganisms enzymatic action is responsible for the rate of decay, what is the activation energy for the decomposition process?

(a) 8.2×10^{-7} kJ/mol (b) 2.34 kJ/mol (c) 23.4 kJ/mol

(d) 67.2 kJ/mol (e) 0.45 kJ/ mol

C **4.** If the rate of a reaction is limited by an activation barrier, if you double the temperature

(a) the rate will double.

(b) the rate will drop in half.

(c) the rate will increase with the magnitude dependent on the activation energy,

(d) the rate will decrease with the magnitude dependent on the activation energy.

(e) the rate might increase or decrease depending on the sign of ΔG.

D **5.** A catalyst will

(a) stabilize the products of a reaction making ΔG more positive.

(b) stabilize the products of a reaction making ΔG more negative.

(c) stabilize the products of a reaction making the reaction more exothermic.

(d) lower the activation barrier for the reaction.

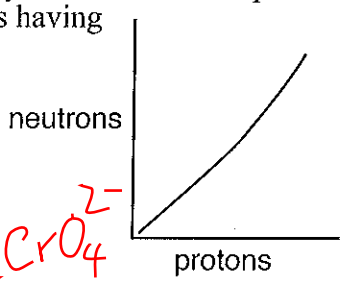
(e) increase the activation barrier of the reaction.

C **6.** Bombarding ^{54}Fe with a neutron results in emission of a proton and formation of

(a) ^{55}Fe (b) ^{54}Cr (c) ^{54}Mn (d) ^{49}Ti (e) ^{54}Fe

A 7. U-236 spontaneously decays to Br-87, X and three neutrons. What is element "X"?
(a) La (b) Ra (c) Ba (d) Pb (e) Th

D 8. Below is a graph representing the band of stability for different isotopes. Nuclides that lie below the band of stability would be described as having
(a) too many electrons
(b) too many isotopes
(c) too many neutrons
(d) too many protons



Hg_2^{2+} CrO_4^{2-} $= x^2$ $x = \sqrt{K_{sp}}$

A B 9. What is the molar solubility of mercury(I) chromate ($K_{sp} = 2.0 \times 10^{-9}$)?
(a) 4.5×10^{-5} M (b) 7.9×10^{-4} M (c) 2.0×10^{-9} M (d) 7.1×10^{-3} M (e) 2.9×10^{-3} M

A. 10. The radioisotope technetium-99 is often used as a radiotracer to detect disorders of the body. It has a half-life of 6.01 hours. If a patient received a 25.0-mg dose of this isotope during a medical procedure, how much would remain 48.0 hours after the dose was given?
(a) 0.098 mg (b) 0.083 mg (c) 0.012 mg (d) 1.062 mg (e) 1.122 mg

True or False Write "T" for true, or "F" for false (2 pts each)

F 11. If a reaction is first order, the rate of the reaction is constant with time.

F 12. For the following reaction, the rate of formation of H_2O will be twice the rate of reaction of H_2.

$$2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

F 13. The rate constant for a reaction is independent of temperature.

T 14. A catalyst will increase the rate of both the forward and backwards reactions.

F 15. $PbCl_2$ is more soluble in 1 M NaCl than in pure water.

F 16. Comparing two salts, the one with the larger K_{sp} is always more soluble.

T 17. Metal hydroxides are always more soluble in acidic solutions.

F 18. Electrons, positrons, and beta particles are all nucleons.

F 19. A lightweight isotope is likely to be stable if the ratio of protons to neutrons in its nucleus is 1:2.

T 20. A catalyst can be present in the rate determining step but not included in the overall reaction.

21. If the rate constant for a reaction at 400°C is double the rate constant at 300°C, what is the activation energy for this reaction? (Give your answer in kJ mol-1). (4 pts)

$K_1 = 2K_2 \quad T_1 = 400°C = 673K \quad T_2 = 300°C = 573K$

$K_1 = Ae^{-Ea/R(673)}$
$K_2 = Ae^{-Ea/R(573)}$ $\Rightarrow \quad \frac{2K_2 = Ae^{-Ea/R(673)}}{K_2 = Ae^{-Ea/R(573)}} \Rightarrow 2 = \frac{e^{-Ea/R(673)}}{e^{-Ea/R(573)}}$

$\ln 2 = \frac{-Ea}{R(673)} - \frac{(-Ea)}{R(573)} = \frac{Ea}{R(573)} - \frac{Ea}{R(673)} = Ea\left[\frac{1}{R(573)} - \frac{1}{R(673)}\right] \Rightarrow Ea = 22.22$ kJ/mol

22. Use the experimental data to determine the following statements for the reaction

$$2\,ICl(g) + H_2(g) \longrightarrow I_2(g) + 2\,HCl(g)$$

[ICl] mol/L	[H_2] mol/L	Initial Rate M s^{-1}
1.5×10^{-3}	1.5×10^{-3}	3.70×10^{-7}
3.0×10^{-3}	1.5×10^{-3}	7.40×10^{-7}
4.5×10^{-3}	4.5×10^{-3}	6.66×10^{-6}

(a) The order of the reaction with respect to ICl(*g*). (1 pts)

$\frac{7.4}{3.7} = \frac{K(3.0)^x(1.5)^y}{K(1.5)^x(1.5)^y} \Rightarrow 2 = 2^x \Rightarrow x = 1$ First order

(b) The order of the reaction with respect to H_2(*g*). (1 pts)

$\frac{66.6}{3.7} = \frac{K(4.5)^1(4.5)^y}{K(1.5)^1(1.5)^y} \Rightarrow 18 = 3(3)^y \Rightarrow 6 = 3^y$ 3/2 order

$y = 1.63 \approx 3/2$

(c) The rate law for the reaction. (2 pts)

$rate = k[ICl][H_2]^{3/2}$

(d) The rate constant for the reaction (in the correct units). (2 pts)

$K = 3.7 \times 10^{-7} / (1.5 \times 10^{-3})(1.5 \times 10^{-3})^{3/2} = 4.25\ M^{-3/2} s^{-1}$

(e) Given the following initial conditions, [H_2] = 10 M, [ICl] = 10^{-4} M, and the concentration of ICl is found to decrease exponentially with time. What will the half-life of ICl be under these conditions? (2 pts) pseudo first order

$rate = k[ICl](10)^{3/2} \Rightarrow k'[ICl]$

$k' = 134.27\ s^{-1}$

$t_{1/2} = \ln 2 / k' = \ln 2 / 134.27\ s^{-1} = 0.0052$ sec

23. Lead Iodide (PbI_2) is an insoluble yellow solid with a $K_{sp} = 1.4 \times 10^{-9}$ at room temperature. If you mix 200 mL of 2.1×10^{-2} M $Pb(NO_3)_2$ solution with 20 mL of 1.2×10^{-3} M KI, will any solid PbI_2 form as precipitate? Explain. (3 pts)

$mol\ Pb^{2+} = (0.2L)(2.1\times10^{-2}M) = 4.2\times10^{-3}$ mols Pb^{2+}

$mol\ I^- = (0.02L)(1.2\times10^{-3}M) = 2.4\times10^{-5}$ mols I^-

$[Pb^{2+}] = 4.2\times10^{-3}\text{ mols} / 0.22L = 0.019M$

$[I^-] = 2.4\times10^{-5}\text{mols} / 0.22L = 1.1\times10^{-4}M$

$Q_{sp} = [Pb^{2+}][I^-]^2 = (0.019)(1.1\times10^{-4})^2 = 2.2\times10^{-10}$

$Q_{sp} < K_{sp}$ ∴ no ppt. will form

24. You attempt to dissolve 0.25 g of $PbCl_2$ in 50 mL of water. You find that all but 0.03 g dissolves.

(a) What is the molar solubility of $PbCl_2$ in water ? (2 pts)

$PbCl_2\ (dissolved) = 0.25g - 0.03g = 0.22g\ PbCl_2 \times \frac{1\ mol}{278\ g} = 7.9\times10^{-4}$ mols

$\frac{7.9\times10^{-4}\text{ mols}}{0.050L} = 1.58\times10^{-2}\ M$

(b) What is the solubility product for $PbCl_2$? (2 pts)

$K_{sp} = [Pb^{2+}][Cl^-]^2$

$= [1.58\times10^{-2}][3.16\times10^{-2}]^2$

$= 1.58\times10^{-5}$

25. Wesley Snipes decides to try and separate Ba^{2+} ions from Mg^{2+} ions in an aqueous solution. He decides to selectively precipitate using carbonate ion. The solution has 0.0050 M barium ion and 0.0035 M magnesium ion in it.

(a) Which ion will precipitate out first? (1 pt)

$5.0\times10^{-9} = [0.0050][CO_3^{2-}]$

$1\times10^{-6} = [CO_3^{2-}]$

$3.5\times10^{-8} = [0.0035][CO_3^{2-}]$

$1\times10^{-5} = [CO_3^{2-}]$

Thus, the barium carbonate will ppt. first

(b) What percentage of this ion still remains in solution when the other ion first begins to precipitate? (3 pts)

$5.0\times10^{-9} = [Ba^{2+}][1\times10^{-5}]$

$5.0\times10^{-4} = [Ba^{2+}]$

$\left(\frac{5.0\times10^{-4}}{0.005}\right)\times100\% = 10\%$

(c) So is this a good way to separate barium and magnesium ions? (1 pt)
K_{sp} (barium carbonate) = 5.0×10^{-9} , K_{sp} (magnesium carbonate) = 3.5×10^{-8}

No, because 10% of the Ba^{2+} will still be in solution once the Mg^{2+} starts to ppt. Generally, you would want 1% of fewer in solution.

26. For the following overall reaction
$4HBr(g) + O_2(g) \rightarrow 2H_2O(g) + 2Br_2(g)$
the following reaction mechanism is proposed:

$HBr(g) + O2(g)$	$\xrightarrow{k_1}$	$HOOBr(g)$	fast
$HOOBr(g) + HBr(g)$	$\xrightarrow{k_2}$	$2\ HOBr(g)$	slow
$2\ HOBr(g) + 2\ HBr(g)$	$\xrightarrow{k_3}$	$2\ H2O(g) + 2\ Br2(g)$	fast

(a) What is the rate limiting step for this reaction ? (1 pts)

The second step

(b) Based on this mechanism what would you propose is the rate law for this reaction? (3 pts)

$$\text{rate} = k_2[HOOBr][HBr]$$
$$[HOOBr] = \frac{k_1}{k_{-1}}[HBr][O_2] \Rightarrow \text{rate} = \frac{k_1 k_2}{k_{-1}}[HBr]^2[O_2]$$

(c) Are there any reaction intermediates? If so what are they? (2 pts)

Yes, $HOOBr(g)$ + $HOBr(g)$

27. Write a complete nuclear equation for each of the following:

(a) The decay of $^{53}_{26}Fe$ by beta emission. (2 pts)

$^{53}_{26}Fe \rightarrow {}^{0}_{-1}\beta + {}^{53}_{27}Co$

(b) The decay of $^{230}_{90}Th$ by alpha emission. (2 pts)

$^{230}_{90}Th \rightarrow {}^{4}_{2}He + {}^{226}_{88}Ra$

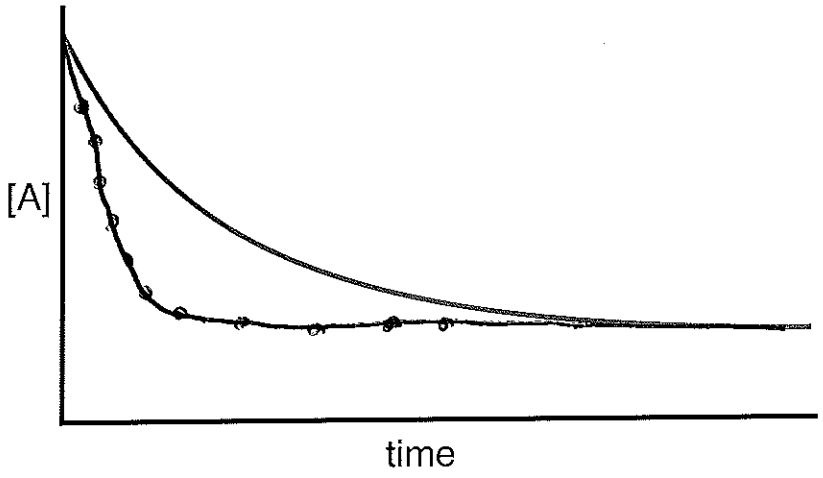
(c) The decay of $^{37}_{18}Ar$ by electron capture. (2 pts)

$^{37}_{18}Ar + ^{0}_{-1}e \rightarrow ^{37}_{17}Cl$

(d) The decay of $^{38}_{19}K$ by positron emission. (2 pts)

$^{38}_{19}K \rightarrow ^{0}_{+1}\beta + ^{38}_{18}Ar$

28. Consider the following plot of the concentration of species "A" as it reacts during a reaction. Correctly draw in the updated profile on the same plot when a catalyst is present. (4 points)



A catalyst does not affect equilibrium position, but increases the rate of the reaction

29. A first order reaction is such that 25% of reactant "X" decomposes into products in about 36 minutes. What is the half-life of X under these conditions? (round answer to the nearest whole minute) (3 points) 75% remains

$[A] = [A]_0 e^{-kt} \Rightarrow k = \frac{\ln\left[\frac{A}{A_0}\right]}{-t} = \frac{\ln\left(\frac{0.75}{1}\right)}{-36}$

$k = 0.00799$

$t_{1/2} = \ln 2 / k = 87 \text{ min}$

30. According to this table of data... (2+2+1 points)

$[H_2O]$ mol/L	$[CO_2]$ mol/L	Initial Rate M s^{-1}
0.045	0.94	4.84×10^2
0.045	0.47	2.42×10^2
0.18	0.94	9.68×10^2

(a) What is the rate law?

$\frac{4.84}{2.42} = \frac{K[0.045]^X[0.94]^Y}{K[0.045]^X[0.47]^Y} \Rightarrow 2 = 2^Y, Y = 1$

$\frac{9.68}{4.84} = \frac{K[0.18]^X[0.94]}{K[0.045]^X[0.94]} \Rightarrow 2 = 4^X = X = 1/2$

(b) What is the value for k?

rate $= K[H_2O]^{1/2}[CO_2]$

$K = \frac{4.84 \times 10^2}{(0.045)^{1/2}(0.94)} = 2427.23\ M^{-1/2}\ s^{-1}$

(c) What are the units on k ?

$M^{-1/2}\ s^{-1}$