56-4=52 +36 +13 +8

$\frac{109}{112}$

MC, Chem1B, Fall11, Lec Test2

Name KEY

Read questions carefully before answering. No outside paper is allowed. Write **set up equation** for a mathematical problem, then put the raw data with **units,** before showing the calculation. Use the reverse side of your answer paper as scratch. Use the periodic table and important constants charts provided. (Total points = 56 + 40 + 16 = 112).

Show your calculation with set up and units (when appropriate)

1) For the equilibrium reaction given below: 1) ____________

$Cu^{2+}(aq) + 4\,NH_3(aq) \leftrightarrow Cu(NH_3)_4{}^{2+}(aq)$

a) Write the equilibrium constant expression for this reaction (4 pts.).

$$K_{eq} = \frac{[Cu(NH_3)_4{}^{2+}]}{[Cu^{2+}][NH_3]^4}$$

To measure the equilibrium constant, 5.0 mL of 1.00 M $Cu(NO_3)_2(aq)$ solution was mixed with 15.0 mL of 1.0 M $NH_3(aq)$ at 25°C. When the equilibrium reached, the absorbance of $Cu(NH_3)_4{}^{2+}(aq)$ at equilibrium was determined using spectroscopy to be 0.31. A standard curve of $Cu(NH_3)_4{}^{2+}(aq)$, plotting the absorbance (y-axis) vs. the concentration (x-axis) gave a straight line with a slope of 1.948 and intercept of 0.0018.

$\text{mole}_{Cu(NO_3)_2} = 0.005L \times 1M = 0.005\ \text{mol}$

$\text{mole}_{NH_3} = 0.015\,L \times 1M = 0.015\ \text{mol}$

$0.31 = 1.948x + 0.0018.$

b) Calculate K_c for this system at 25°C (10 pts.). $\Rightarrow x = 0.16$

$Cu(NO_3) \longrightarrow Cu^{2+} + 2NO_3^-$

(mol) 0.005   0.005

	Cu^{2+}	$+\ 4\,NH_3$	$\rightleftharpoons Cu(NH_3)_4{}^{2+}$
I	0.25M	0.75	0
C	$-x$	$-4x$	$+x$
E	$0.25-x$	$0.75-4x$	$+x$
	(0.09)	0.11	

$$[Cu^{2+}] = \frac{0.005\ \text{mol}}{(5+15)\times10^{-3}\,L} = 0.25\,M$$

$$[NH_3] = \frac{0.015\ \text{mol}}{(5+15)\times10^{-3}\,L} = 0.75\,M$$

$$K_c = \frac{[Cu(NH_3)_4{}^{2+}]}{[Cu^{2+}][NH_3]^4} = \frac{0.16}{(0.25-0.16)(0.75-4\times0.16)^4}$$

$= 1.2\times10^4$

2) In the equilibrium rxn. Butane (g) ↔ Isobutane (g), assume equlibrium has reached in a 1.0 L flask with [Butane] = 0.5 M and [Isobutane] = 1.23 M at 298 K. The equlibrium constant for the reaction = 2.5 and afterwards 1.5 mol of Butane was added to the mixture. Calculate the new values of [Butane] and [Isobutane] when equilibrium was reestablished (8 pts.)? 2) ____________

$$[\text{butane}]_{\text{after adding}} = \frac{0.5M\times1.0L + 1.5\,\text{mol}}{1.0L} = 2.0\,M$$

	Butane	$\rightleftharpoons$ Isobutane
I	2.0M	1.23M
C	$-x$	$+x$
E	$2.0-x$	$1.23+x$

$$K_{eq} = \frac{[\text{isobutane}]}{[\text{butane}]} = \frac{1.23+x}{2.0-x} = 2.5$$

$\Rightarrow x = 1.1\ M$

$\Rightarrow [\text{butane}]_{eq} = 2.0-1.1 = 0.9\ (M)$

$[\text{isobutane}]_{eq} = 1.23+1.1 = 2.33\ (M)$

$$M = \frac{n}{V}$$

0.5M CH_3COOH

3) 200.0 ml of a solution containing 0.5000 moles of acetic acid per liter is added to 200.0 ml of 0.5000 M NaOH. What is the final pH? The Ka of acetic acid is 1.770 × 10^{-5} (10 pts) (Note: Check what components you have in the final solution.) 3) ______________

$$CH_3COOH + OH^- \rightleftharpoons CH_3COO^- + H_2O$$

	CH_3COOH	OH^-	CH_3COO^-
I	0.1 mol	0.1 mol	
C	− 0.1 mol	− 0.1 mol	+0.1 mol
After	0	0	0.1 mol

mole CH_3COOH = 0.5M × 0.2L = 0.1 mol

mole $NaOH$ = 0.5M × 0.2L = 0.1 mol

$$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$$

	CH_3COO^-	CH_3COOH	OH^-
I	0.25M	0	0
C	$-x$	$+x$	$+x$
E	$(0.25-x)$	$+x$	x

$$[CH_3COO^-] = \frac{0.1\ mol}{(0.2+0.2)L} = 0.25M$$

$$K_b = \frac{10^{-14}}{1.770 \times 10^{-5}} = 5.65 \times 10^{-10}$$

$$\Rightarrow \frac{[OH^-][CH_3COOH]}{[CH_3COO^-]} = 5.65 \times 10^{-10}$$

$$\Rightarrow \frac{x^2}{0.25-x} = 5.65 \times 10^{-10}$$

1.18×10^{-5}

$$\Rightarrow x = 2.82 \times 10^{-5} = [OH^-]$$

$$\Rightarrow pOH = -\log[OH^-] = 4.55$$

4.92

$$\Rightarrow pH = 14 - 4.55 = 9.45$$

pH = 9.075

4) Calculate the pH of a buffer solution that contains 0.820 grams of sodium acetate and 0.01 moles of acetic acid in 100 ml of water. The Ka of acetic acid is 1.77 × 10^{-5} (8 pts). 4) ______________

CH_3COONa : 0.82g $\Rightarrow$ mole $= \frac{0.82\ g}{82\ g/mol} = 0.01\ mol \Rightarrow [CH_3COONa] = \frac{0.01 mol}{0.1\ L} = 0.1M$

$$CH_3COONa \rightarrow CH_3COO^- + Na^+$$

0.1M 0.1M

$$[CH_3COOH] = \frac{0.01 mol}{0.1 L} = 0.1M$$

$$CH_3COOH + H_2O \rightleftharpoons CH_3COOH^- + H_3O^+$$

	CH_3COOH	CH_3COOH^-	H_3O^+
I	0.1M	0.1M	0
C	$-x$	$+x$	$+x$
E	$0.1-x$	$0.1+x$	$+x$

$$K_a = \frac{(0.1+x)x}{(0.1-x)} = 1.77 \times 10^{-5}$$

$$\Rightarrow x = 1.77 \times 10^{-5} = [H_3O^+]$$

$$pH = -\log[H_3O^+] = -\log[1.77 \times 10^{-5}]$$

$$= 4.75$$

OR using Hendersen-Hasselbach Eqn

$$pH = pKa + \log\frac{[conj\ base]}{[Acid]}$$

$$= pKa + \log\frac{[acetate]}{[acetic\ acid]}$$

$$pH = pKa + \log\frac{.1}{.1}$$

$$pH = pKa + \log 1$$

$$= pKa + 0$$

$$pH = pKa = -\log Ka$$

$$pH = -\log(1.77 \times 10^{-5})$$

$$= 4.75$$

5) Calculate the molar solubilty of CaF_2 at 25°C in a solution that is 0.010 M in $Ca(NO_3)_2$. Ksp for $CaF_2 = 3.9 \times 10^{-11}$. Show your calculation with ICE chart. (8 pts.) 5) ____________

$Ca(NO_3)_2 \rightarrow Ca^{2+} + 2NO_3^-$

0.01M   0.01M

	$CaF_2(s)$	$\rightleftharpoons$	Ca^{2+}	$+ 2F^-$
I			0.01M	
C	$-s$		$+s$	$+2s$
E			$0.01+s$	$2s$

$K_{sp} = [Ca^{2+}][F^-]^2 = 3.9\times10^{-11}$

$\Rightarrow (0.01+s)(2s)^2 = 3.9\times10^{-11}$

$\Rightarrow 4s^2 \approx \frac{3.9\times10^{-11}}{0.01}$

$\Rightarrow s^2 = 9.75\times10^{-10}$

$\Rightarrow s = 3.12\times10^{-5}$ (M)

PbI_2

6) Calculate the concentration of iodide ions in a saturated solution of lead (II) iodide. The solubility product constant of PbI_2 is 1.4×10^{-8} (8 pts.). 6) ____________

	$PbI_2(s)$	$\rightleftharpoons$	$Pb^{2+}(aq)$	$+ 2I^-(aq)$
C	$-s$		s	$2s$
E			s	$2s$

$K_{sp} = [Pb^{2+}][I^-]^2 = 1.4\times10^{-8}$

$\Rightarrow s\cdot(2s)^2 = 1.4\times10^{-8}$

$\Rightarrow 4s^3 = 1.4\times10^{-8}$

$\Rightarrow s^3 = 3.5\times10^{-9}$

$\Rightarrow s = 1.52\times10^{-3}$ (M).

-3

$[I^-] = 2.s = 2\times1.52\times10^{-3}$
$= 3.04\times10^{-3}$

$pH = pk_a$

MULTIPLE CHOICE. Select the one alternative that best completes the statement or answers the question (4 pts each).

7) In a solution, when the concentrations of a weak acid and its conjugate base are equal, 7) B

A) the system is not at equilibrium.
B) the $-\log$ of the $[H^+]$ and the $-\log$ of the K_a are equal. $= 0$
C) the buffering capacity is significantly decreased.
D) all of the above are true.

8) How does the reaction quotient of a reaction (Q) differ from the equilibrium constant (K_{eq}) of the same reaction? 8) B

A) K does not depend on the concentrations or partial pressures of reaction components.
[✓ B)] Q is the same as K_{eq} when a reaction is at equilibrium. ✓
C) Q does not depend on the concentrations or partial pressures of reaction components.
D) K_{eq} does not change with temperature, whereas Q is temperature dependent.
E) Q does not change with temperature.

9) The K_{eq} for the equilibrium below (K_1) is 7.52×10^{-2} at 480 °C. 9) C

$$2Cl_2 (g) + 2H_2O (g) \rightleftharpoons 4HCl (g) + O_2 (g)$$

What is the value of K_{eq} at this temperature for the following reaction?

revers
chia 2

$$2HCl (g) + \frac{1}{2}O_2 (g) \rightleftharpoons Cl_2 (g) + H_2O (g)$$

A) 13.3
B) 0.274
[✓ C)] 3.65
D) -0.0376
E) 5.66×10^{-3}

$$K_2 = \frac{1}{(K_1)^{1/2}}$$

10) For the endothermic reaction $\longrightarrow$ 10) C

$$CaCO_3 (s) \rightleftharpoons CaO (s) + CO_2 (g)$$

$+\Delta H$

Le Chatelier's principle predicts that __________ will result in an increase in the number of moles of CO_2.

A) removing some of the $CaCO_3$ (s)
B) decreasing the temperature
[✓ C)] increasing the temperature
D) increasing the pressure
E) adding more $CaCO_3$ (s)

↓T pink ←

↑T blue

11) The equlibrium reaction $Co(H_2O)_6^{2+}$ (aq) (Pink) + 4 Cl^- (aq) <-> $CoCl_4{}^{2-}$ (aq) (Blue) + 6 H_2O(l) turns pink when placed in ice water mixture but turns blue in hot water. The reaction, as shown, is: 11) B

↓T ↑T

A) Nonthermic [✓ B) Endothermic]

C) Exothermic D) Insufficient data

12) In which of the following aqueous solutions would you expect AgBr to have the lowest solubility? 12) D

A) 0.10 M $AgNO_3$

B) 0.15 M KBr

C) 0.10 M LiBr

[✓ D) 0.20 M NaBr]

X [✓ E) pure water]

$AgBr \rightleftharpoons Ag + Br$

0.1

$6.25\times10^{-3}(0.1-s)$ s

6.25×10^{-3}

13) The pH of a solution prepared by mixing 50.0 mL of 0.125 M KOH and 50.0 mL of 0.125 M HCl is __________. 13) C

A) 8.11 B) 5.78 [✓ C) 7.00] D) 0.00 E) 6.29

14) Which one of the following pairs cannot be mixed together to form a buffer solution? 14) E

A) $NaC_2H_3O_2$, HCl ($C_2H_3O_2^-$ = acetate)

B) NH_3, NH_4Cl

C) KOH, HF

D) H_3PO_4, KH_2PO_4 /

[✓ E) RbOH, HBr]

15) Which below best describe(s) the behavior of an amphoteric hydroxide in water? 15) C

A) With conc. aq. HCl, its clear solution forms a precipitate.

B) With conc. aq. NaOH, its suspension dissolves.

[✓ C) With both conc. aq. NaOH and conc. aq. HCl, its suspension dissolves.]

D) With conc. aq. HCl, its suspension dissolves.

E) With conc. aq. NaOH, its clear solution forms a precipitate.

??

16) Given K_{sp} for $Zn3(PO4)2$ (s) is 9.0 x 10^{-33} and that K_f for $[Zn(OH)4]^{2-}$ is 4.6 x 10^{17} for the formation of the complex from Zn^{2+} and OH^-, calculate the K_{net} for the following reaction: 16) A

$Zn3(PO4)2$ (s) + 12 OH^- (aq) ------> 3 $[Zn(OH)4]^{2-}$ (aq)+ 2 $PO4^{3-}$ (aq). Ksp

$3\,[Zn(OH)_4]^{2-} \rightleftharpoons 3Zn^{2+} + \cancel{4OH^-}$ Kf

[✓ A) 8.76 x 10^{20}] B) 8.76 x 10^{-16} C) 4.14 x 10^{15} D) 4.14 x 10^{-15}

TRUE/FALSE. Circle 'A' if the statement is true and 'B' if the statement is false (2 pts each) and then provide a short explanation (2 pts. each).

17) The solubility product of a compound is numerically equal to the product of the concentration of the ions involved in the equilibrium, each multiplied by its coefficient in the equilibrium reaction. T or [✓ F] ✓

- not equal
- multiplied by its coefficiant in the equilibrium is not correct. then what ?

-1

18) The solubility of slightly soluble salts containing basic anions is proportional to the pH of the solution. T or [✓ F] ✓

it is a buffer solution. NO

⇒ resist the change of pH if adding slightly soluble salts containing basic anions.

-2

19) At constant temperature, reducing the volume of a gaseous equilibrium mixture causes the reaction to shift in the direction that increases the number of moles of gas in the system. T or [✓ F] ✓

$C_M = \frac{n}{V}$ if $V \downarrow \Rightarrow C_M \uparrow$

⇒ to reequilibrium. the rxn has to shift in the direction that decreasing the number of moles of gas.

20) The effect of a catalyst on a chemical reaction is to react with product, effectively removing it and shifting the equilibrium to the right. T or [✓ F] ✓

catalyst does not react with reactants or products.

It decrease E_a of reaction

Show your calculation with set up and units (when appropriate)

21) **Extra point question:** Show your calcualtion to predict if a precipitate will form when 0.10 L of 8.0x10^{-3} M $Pb(NO_3)_2$ is added to 0.40 L of 5.0 x 10^{-3} M Na_2SO_4 solution. Ksp of $PbSO_4$ =6.3x10^{-7} . Calculate [Pb^{2+}] in the mixture (2 pts.) calculate [SO_4^{2-}] in the mixture (2 pts.); calculate Q (2 pts.); state reason if precipitate will form or not (2 pt.). (Total 8 pts.)

21) ______________

$$\text{mole}_{Na_2SO_4} = 5.0\times10^{-3} M \times 0.4 L = 2.0\times10^{-3} \text{mol}$$

$$\underset{2.0\times10^{-3}\text{mol}}{Na_2SO_4} \longrightarrow 2Na^+ + \underset{2.0\times10^{-3}\text{mol}}{SO_4^{2-}}$$

$$\text{mole}_{Pb(NO_3)_2} = 8.0\times10^{-3} M\times 0.1L = 8.0\times10^{-4} \text{mol}$$

$$\underset{8.0\times10^{-4}\text{mol}}{Pb(NO_3)_2} \longrightarrow \underset{8.0\times10^{-4}\text{mol}}{Pb^{2+}} + 2NO_3^-$$

$$PbSO_4(s) \rightleftharpoons Pb^{2+} + SO_4^{2-}$$

$$\text{I(mol)} \quad 8.0\times10^{-4} \quad 2.0\times10^{-3}$$

$$[Pb^{2+}] = \frac{8.0\times10^{-4}\text{mol}}{(0.1+0.4)L} = 1.6\times10^{-3} M$$

$$[SO_4^{2-}] = \frac{2.0\times10^{-3}\text{mol}}{(0.1+0.4)L} = 4\times10^{-3} M$$

$$Q = [Pb^{2+}][SO_4^{2-}] = 1.6\times10^{-3}\times4\times10^{-3}$$

$$= 6.4\times10^{-6} > K_{sp} \ (6.3\times10^{-7})$$

$\Rightarrow Q > K_{sp}$

⇒ rxn shifts to the left

⇒ the precipitate will form ✓