$62 - 0 = 62$
$\frac{51}{113}$

MC, Chem1B, Spring15, Midterm2

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 = 62 + (17*3=)51 = 113).

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

1) In the reaction N_2 (g) + 3 H_2 (g) ↔ 2 NH_3 (g), if the K_c = 9.60 at 573 K, then calculate the Kp at this temperature (4 pts.).

1) 4.34×10^{-3}

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

$K_p = 9.6(0.0821 \times 573)^{(2-4)}$

$K_p = 9.6(47.0433)^{-2}$

$K_p = 4.34 \times 10^{-3}$ ✓

2) Equilibrium was established when a mixture of 0.20 mol of NO(g), 0.10 mol of H_2(g), and 0.20 mol of H_2O(g) is placed in a 2.0-L vessel at 400 K. The equilibrium reaction is : 2 NO(g) + 2 H_2(g) <—> N_2(g) + 2 H_2O(g). If at equilibrium [NO] = 0.062 *M*, then calculate K_p. (10 pts.)

2) 19.91

0.2 mol NO(g) → $\frac{0.2 \text{ mol}}{2 \text{ L}}$ → 0.1M

0.1 mol H_2(g) → $\frac{0.1 \text{ mol}}{2 \text{ L}}$ → 0.05M

0.2 mol H_2O(g) → $\frac{0.2 \text{ mol}}{2 \text{ L}}$ → 0.1M

	2NO(g)	+ 2H_2(g)	⇌ N_2(g)	+ 2H_2O(g)
I	0.1	0.05	∅	0.1
C	−2x	−2x	+x	+2x
E	0.1−2x	0.05−2x	x	0.1+2x

$[NO]_{eq} = 0.062 = 0.1 - 2x \rightarrow 2x = 0.038 \rightarrow x = 0.019$

$K_c = \frac{[H_2O]^2[N_2]}{[NO]^2[H_2]^2}$

$K_c = \frac{(0.138)^2(0.019)}{(0.062)^2(0.012)^2}$

$K_c = 653.68$

$[H_2]_{eq} = 0.05 - 2(0.019) = 0.012$

$[N_2]_{eq} = 0.019$

$[H_2O]_{eq} = 0.1 + 2(0.019) = 0.138$

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

$K_p = 653.68(0.0821 \times 400)^{(3-4)}$

$K_p = 19.91$ ✓

[Isobutane] = 2.33M

3) 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.)?

3) [butane] = 0.9M

[butane] = $\frac{0.5 + 1.5 \text{ mol}}{1 L}$ = 2

butane (g) ⇌ isobutane (g)

	butane	isobutane
I	2M	1.23M
C	-x	+x
E	2-x	1.23+x

Keq = 2.5 = $\frac{[\text{isobutane}]}{[\text{butane}]}$

$2.5 = \frac{1.23+x}{2-x}$

$5 - 2.5x = 1.23 + x$

$3.5x = 3.77$

$x = 1.1$

[butane] = 2-1.1 = **0.9 M = [butane]**

[isobutane = 1.23+1.1 = **2.33M = [isobutane]**

✓

4) Calculate the pH of a solution if 1.35 moles of NaOH is in 530.00 mL of water. (8 pts.)

4) 14.40

1.35 moles / 0.53 L = 2.5M NaOH

NaOH = strong base, so [NaOH] = [OH^-] = 2.5M

pOH = -log(2.5) → pOH = -0.40

pH = 14 - pOH → pH = 14 - (-0.40) → **pH = 14.40**

✓

5) What is the pH and the pOH of a 0.050M HClO; Ka of HClO is 3.5×10^{-8}. Show your calculation with ICE chart (if necessary). (6+2 = 8 pts.)

5) pH = 4.38
pOH = 9.62

$HClO + H_2O \rightleftharpoons ClO^- + H_3O^+$

	HClO		ClO^-	H_3O^+
I	0.05M		∅	∅
C	-x		+x	+x
E	0.05M - x		x	x

$Ka = \frac{[ClO^-][H_3O^+]}{[HClO]} \rightarrow 3.5 \times 10^{-8} = \frac{(x)(x)}{0.05 - x}$

$3.5 \times 10^{-8} \times 100 = 3.5 \times 10^{-6} < 0.05$
∴ neglect x compared to [HClO]initial

$3.5 \times 10^{-8} = \frac{x^2}{0.05} \rightarrow 2.0 \times 10^{-9} = x^2 \rightarrow x = 4.18 \times 10^{-5} = [H_3O^+]$

pH = -log[H_3O^+] → pH = -log(4.18×10^{-5}) → **pH = 4.38**

✓

pOH = 14 - pH → pOH = 14 - 4.38 → **pOH = 9.62**

$\frac{0.01 \text{ mol } CH_3COOH}{0.1 L} \rightarrow 0.1M \ CH_3COOH$

6) 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). 6) 4.75

$\frac{0.82 g \ NaCH_3COO}{} \left| \frac{1 \text{ mol}}{82 g \ NaCH_3COO} \right. = \frac{0.01 \text{ mol } NaCH_3COO}{0.1 L} \rightarrow 0.1 M \ NaCH_3COO$

$pH = pka + \log \frac{[\text{conj. base}]}{[\text{acid}]} \rightarrow pH = pka + \log \frac{0.1M}{0.1M} \rightarrow pH = pka$

$pka = -\log ka \rightarrow pka = -\log(1.77 \times 10^{-5}) \rightarrow pka = \boxed{4.75 = pH}$ ✓

7) Calculate the pH of a 0.7M NaClO solution. For your calculation show what happens in a stepwise fashion . Ka of HClO is 3.448x10^{-8} (8 pt.) 7) 10.65

$0.7M \ NaClO \rightarrow 0.7M \ Na \ \& \ 0.7M \ ClO^-$

	$ClO^- + H_2O$	$\rightleftharpoons ClOH$	$+ OH^-$
I	0.7	∅	∅
C	$-x$	$+x$	$+x$
E	$0.7-x$	x	x

$K_b = \frac{K_w}{K_a} \rightarrow K_b = \frac{10^{-14}}{3.448 \times 10^{-8}}$

$K_b = 2.9 \times 10^{-7}$ ✓

$K_b = \frac{[OH^-][ClOH]}{[ClO^-]}$

$2.9 \times 10^{-7} = \frac{(x)(x)}{0.7-x}$

$2.9 \times 10^{-7} \times 100 = 2.9 \times 10^{-5} < 0.7$
∴ neglect x compared to $[ClO^-]_{initial}$

$2.9 \times 10^{-7} \approx \frac{x^2}{0.7} \rightarrow 2.03 \times 10^{-7} = x^2 \rightarrow x = 4.5 \times 10^{-4} = [OH^-]$

$pOH = -\log[OH^-] \rightarrow pOH = -\log(4.5 \times 10^{-4}) \rightarrow pOH = 3.35$

$pH = 14 - pOH \rightarrow pH = 14 - 3.35 \rightarrow \boxed{pH = 10.65}$ ✓

8) 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 = 3.9×10^{-11}. Show your calculation with ICE chart (8 pts.). 8) 3.12×10^{-5} moles per 0.1 Liters

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

0.01M → 0.01M 0.02M

$CaF_2(s) \rightleftharpoons Ca^{2+} + 2F^-$

I 0.01M ∅

C −s +s +2s

E 0.01+s 2s

$3.9 \times 10^{-11} \times 100 = 3.9 \times 10^{-9} < 0.01$ ∴ neglect s compared to 0.01

$Ksp = [F^-]^2[Ca^{2+}] \rightarrow 3.9 \times 10^{-11} = (2s)^2(0.01+s)$

$3.9 \times 10^{-11} = 4s^2(0.01) \rightarrow 3.9 \times 10^{-9} = 4s^2 \rightarrow 9.75 \times 10^{-10} = s^2$

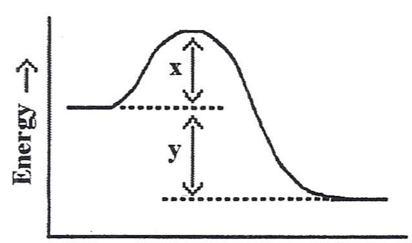
$s = 3.12 \times 10^{-5}$ mol / 0.1 L ✓

MULTIPLE CHOICE. On your scantron, start answering from number 9. Select the one alternative that best completes the statement or answers the question (3 pts each).

9) As the temperature of a reaction is increased, the rate of the reaction increases because the ________. 9) C

A) reactant molecules collide less frequently and with greater energy per collision
B) activation energy is lowered
C) reactant molecules collide more frequently and with greater energy per collision
D) reactant molecules collide less frequently
E) reactant molecules collide more frequently with less energy per collision

10) Which energy difference in the energy profile below corresponds to the activation energy for the forward reaction? 10) A



A) x B) y C) y - x D) x - y E) x + y

11) How does the reaction quotient of a reaction (Q) differ from the equilibrium constant (K_{eq}) of the same reaction? 11) 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.

12) The equilibrium constant for reaction 1 is K. The equilibrium constant for reaction 2 is ________. 12) E

K_1 (1) $SO_2 (g) + (1/2) O_2 (g) \rightleftharpoons SO_3 (g)$
K_2 (2) $2SO_3 (g) \rightleftharpoons 2SO_2 (g) + O_2 (g)$

$\frac{1}{K_2}$ $2SO_2 + O_2 \rightleftharpoons 2SO_3$
$\left(\frac{1}{K_2}\right)^{1/2}$ $SO_2 + \frac{1}{2}O_2 \rightleftharpoons SO_3$

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

A) 1/2K B) K^2 C) $-K^2$ D) 2K E) $1/K^2$

13) The reaction below is exothermic: gives off heat 13) B

$2SO_2 (g) + O_2 (g) \rightleftharpoons 2SO_3 (g)$ $+ \Delta H$

Le Châtelier's Principle predicts that ________ will result in an increase in the number of moles of SO_3 (g) in the reaction container.

A) removing some oxygen → ↓ SO_3
B) increasing the pressure → ↑ SO_3
C) increasing the volume of the container → ↓ SO_3
D) decreasing the pressure → ↓ SO_3
E) increasing the temperature → ↓ SO_3

14) 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: 14) B

ΔH

A) Nonthermic
B) Endothermic
C) Exothermic
D) Insufficient data

(ice) ↓ heat: → pink
pink + heat ⇌ Blue
↑ heat : → blue

15) In which of the following aqueous solutions does the weak acid exhibit the highest percentage ionization? 15) D

A) 0.01 M HClO ($K_a = 3.0 \times 10^{-8}$)
B) 0.01 M HNO_2 ($K_a = 4.5 \times 10^{-4}$)
C) 0.01 M $HC_2H_3O_2$ ($K_a = 1.8 \times 10^{-5}$)
D) 0.01 M HF ($K_a = 6.8 \times 10^{-4}$)
E) These will all exhibit the same percentage ionization.

16) Which of the following aqueous solutions has the highest $[OH^-]$? 16) E

A) a solution with a pOH of 12.0

B) a 1×10^{-3} M solution of NH_4Cl

C) a 1×10^{-4} M solution of HNO_3

D) a solution with a pH of 3.0

E) pure water

17) A 0.1 M aqueous solution of ________ will have a pH of 7.0 at 25.0 °C. 17) B

NaOCl KCl NH_4Cl $Ca(OAc)_2$

A) NaOCl

B) KCl

C) NH_4Cl

D) $Ca(OAc)_2$

E) KCl and NH_4Cl

18) Which one of the following pairs cannot be mixed together to form a buffer solution? 18) 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

TRUE/FALSE. On the scantron, select answer 'A' if the statement is true and 'B' if the statement is false (3 pts each).

19) H_2SO_3 and H_2SO_4 are considered an acid-base conjugate pair. T or F

20) The conjugate base to HSO_4^- is SO_4^{2-}. T or F

21) The extent of ionization of a weak electrolyte is ~~increased~~ decreased by adding to the solution a strong electrolyte that has an ion in common with the weak electrolyte. T or F

22) 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~~ raised to the power of its coefficient in the equilibrium reaction. T or F

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

$\downarrow V = \uparrow P$: $\downarrow$ # moles

24) In an exothermic equilibrium reaction, increasing the reaction temperature favors the formation of reactants. T or F

reactant(s) $\rightleftharpoons$ product(s) + heat

25) The solubility of slightly soluble salts containing basic anions is proportional to the pH of the solution. T or F ?