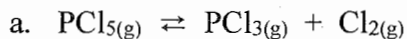


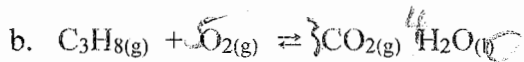
Academic Honesty: The answers on this test are my own and I am using only the allowed set of notes as described in the syllabus / test directions. I have not discussed the test questions with anyone before or during the test nor have I seen the test questions prior to the exam. I will not use any online resources except google classroom and any links in the test directions during the test. If you violate any of the preceding items or do not sign, your semester grade is a F.

Signature: _____

1. Write the Kc expression of the below chemical equations. [15 points]



$K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]}$

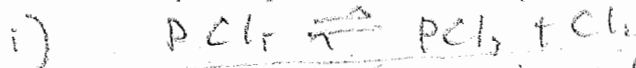


$K_c = \frac{[\text{CO}_2]^3}{[\text{C}_3\text{H}_8][\text{O}_2]^5}$



$K_c = [\text{Ca}^{2+}]^3 [\text{PO}_4^{3-}]^2$

2. Assume $K_p = 10$ for the reaction: $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$. If the initial partial pressure of PCl_5 is 2.0 atm, what is the partial pressure of Cl_2 at equilibrium? [10 points]



I	2.0	0	0
C	-x	+x	+x
E	2-x	x	x

ii) $K_p = \frac{P_{\text{Cl}_2} \cdot P_{\text{PCl}_3}}{P_{\text{PCl}_5}}$

$10 = \frac{x \cdot x}{2-x}$

$x = 1.7 \text{ atm}$

3. In regards to the reaction: $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ at equilibrium and it is an endothermic reaction, what happens to the number of moles of chlorine gas due to ... basis / rationale? [20 points]

a. the removal of PCl_5 at constant temperature and volume

5 pts
 $\text{removal PCl}_5 \rightarrow \downarrow n_{\text{PCl}_5} \rightarrow \uparrow Q \rightarrow$ to reestablish equilibrium
 \downarrow
 $\downarrow n_{\text{Cl}_2} \leftarrow \uparrow n_{\text{PCl}_3} \leftarrow \downarrow Q$

b. the addition of PCl_3 at constant temperature and volume

add $\text{PCl}_3 \rightarrow \uparrow n_{\text{PCl}_3} \rightarrow \uparrow Q \rightarrow$ to reestablish equilibrium
 \downarrow
 $\downarrow n_{\text{Cl}_2} \leftarrow \uparrow n_{\text{PCl}_3} \leftarrow \downarrow Q$

c. the addition of helium, an inert gas, at constant temperature and volume

$\downarrow n_{\text{Cl}_2}$ b/c He is inert & not part of Q

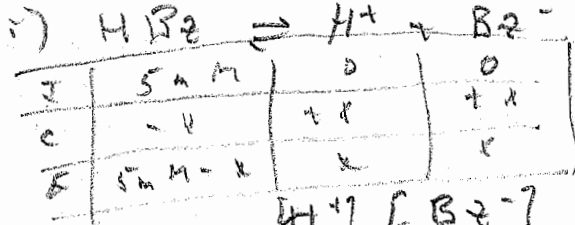
d. the addition of helium, an inert gas, at constant temperature and pressure

add He $\rightarrow \uparrow n_{\text{total}} \rightarrow \uparrow P \rightarrow \uparrow V$ to maintain P $\rightarrow \downarrow Q$
 \downarrow
 $\uparrow n_{\text{Cl}_2} \leftarrow \uparrow n_{\text{PCl}_3} \leftarrow \uparrow Q$ to reestablish equilibrium

e. cooling the solution

~~$\Delta H = \Delta H_f \text{Cl}_2 + \Delta H_f \text{PCl}_3 - \Delta H_f \text{PCl}_5$~~
 from b/c unable to find $\Delta H_f \text{PCl}_5$

4. What is the pH of a 75.0 mL aqueous solution of 5.0 mM benzoic acid, C₆H₅COOH? [15 points]



ii) $K_a = \frac{[\text{H}^+][\text{Bz}^-]}{[\text{HBz}]}$

$6.3 \cdot 10^{-5} = \frac{x^2}{0.005 - x} \approx \frac{x^2}{0.005}$

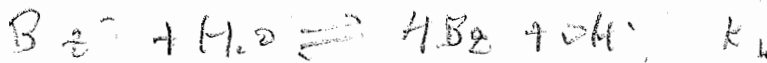
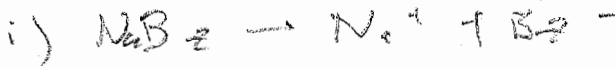
$x = \sqrt{0.005 (6.3 \cdot 10^{-5})}$

$= 5.6 \cdot 10^{-4}$

iii) $\text{pH} = -\log [\text{H}^+] = -\log (5.6 \cdot 10^{-4}) = \boxed{3.25}$

5 pts

5. What is the pH of a 75.0 mL aqueous solution of 5.0 mM sodium benzoate, C₆H₅COONa? [20 points]



I	5 mM	0	0
C	-x	+x	+x
E	5 mM - x	x	x

ii) $K_b = \frac{K_w}{K_a} = \frac{[\text{HBz}][\text{OH}^-]}{[\text{Bz}^-]}$

$\frac{10^{-14}}{6.3 \cdot 10^{-5}} = \frac{x^2}{0.005 - x} \approx \frac{x^2}{0.005}$

$1.59 \cdot 10^{-10} = \frac{x^2}{0.005}$

$x = 8.92 \cdot 10^{-7}$

(ii) $[\text{H}^+][\text{OH}^-] = K_w$

$[\text{H}^+] = 1.12 \cdot 10^{-7}$

(i) $\text{pH} = -\log [\text{H}^+] = \boxed{7.95}$

$\boxed{7.95}$

5 pts

6. old topic: which isomer, the ether, CH₃OCH₃, or the alcohol, CH₃CH₂OH, has the higher vapor pressure? basis / rationale? [10 points]

• dipole-dipole
• London

• H-bonding
• London

• Same London b/c isomers • Same w/e- / polarizability

• ↑ VP ← ↑ gas ← easier to evaporate ← ↓ IMF : BORN like H-bond > dipole-dipole or dipole-dipole < H-bond