ch. 15, 16, & 19.7 equilibrium **test** 70 points (20 ec) ap chem

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]
   a. $PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

   b. $C_3H_{8(g)} + 5O_{2(g)} \rightleftarrows 3CO_{2(g)} + 4H_2O_{(l)}$

$$K_c = \frac{[CO_2]^3}{[C_3H_8][O_2]^5}$$

   c. $Ca_3(PO_4)_{2(s)} \rightleftarrows 3Ca^{+2}_{(aq)} + 2PO^{-3}_{4(aq)}$

$$K_c = [Ca^{+2}]^3 [PO_4^{-3}]^2$$

2. Assume Kp = 10 for the reaction: $PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$. 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)

$$PCl_5 \rightleftarrows PCl_3 + Cl_2$$

	PCl_5	PCl_3	Cl_2
I	2.0	0	0
C	$-x$	$+x$	$+x$
E	$2-x$	x	x

ii)

$$K_p = \frac{P_{PCl_3} P_{Cl_2}}{P_{PCl_5}}$$

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

$$x = 1.71 \text{ atm}$$

$K_c = \frac{n_{Cl_2} n_{PCl_3}}{n_{PCl_5}} \cdot \frac{\left(\frac{1}{V}\right)^2}{\left(\frac{1}{V}\right)} \rightarrow \frac{n_{Cl_2} n_{PCl_3}}{n_{PCl_5}}$

3. In regards to the reaction: $PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$ 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 pt @ remove PCl_5 → ↓ n_{PCl_5} → ↑ Q → to reestablish eq with ↓ n_{Cl_2} ← ↑ r_b ← ↓ Q

b. the addition of PCl_3 at constant temperature and volume

add PCl_3 → ↑ n_{PCl_3} → ↑ Q → to reestablish eq with ↓ n_{Cl_2} ← ↑ r_b ← ↓ Q

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

↑ n_{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 → ↑ n_{tot} → ↑ P → ↑ V to maintain P → ↓ Q → ↑ n_{Cl_2} ← ↑ r_b ← ↑ Q to reestablish equilibrium

e. cooling the solution

~~ΔH = ΔH_f Cl_2 + ΔH_f PCl_3 − ΔH_f PCl_5~~

from b/c unable to find ΔH_f PCl_5

4. What is the pH of a 75.0 mL aqueous solution of 5.0 mM benzoic acid, C_6H_5COOH ? [15 points]

i) $HBz \rightleftharpoons H^+ + Bz^-$

	HBz	H^+	Bz^-
I	5 mM	0	0
C	− x	+ x	+ x
E	5 mM − x	x	x

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

5 pt @

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

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

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

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

5. What is the pH of a 75.0 mL aqueous solution of 5.0 mM sodium benzoate, C_6H_5COONa ? [20 points]

i) $NaBz \rightarrow Na^+ + Bz^-$

$Bz^- + H_2O \rightleftharpoons HBz + OH^-$ K_b

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

5 pt @

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

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

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

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

iii) $[H^+][OH^-] = K_w$

$[H^+] = 1.12 \cdot 10^{-8}$

iv) $pH = -\log [H^+]$

$= \boxed{7.95}$

6. old topic: which isomer, the ether, CH_3OCH_3, or the alcohol, CH_3CH_2OH, has the higher vapor pressure ? basis / rationale ? [10 points]

- dipole-dipole → London
- H-bond → London
- same London b/c isomers ⇒ same MW / polarizability
- ↑ VP ← ↑ gas ← easier to evaporate ← ↓ IMF ; ROR: dipole-dipole > London ; ROH: H-bond > dipole-dipole