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McCord CH302

unique: 50015

MWF 2pm - 3pm

Exam 2

Fall 2018

Oct 17, 2018

Wednesday 7:30 - 9:00 PM

BUR 106

Remember to refer to the Periodic Table handout that is separate from this exam copy.

NOTE: Please keep this exam copy intact (all pages still stapled - including this cover page). You must turn in ALL the materials that were distributed. This means that you turn in your exam copy (name and signature included), bubble sheet, periodic table handout, and all scratch paper. Please also have your UT ID card ready to show as well.

This print-out should have 25 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 4.0 points

Which solution is acidic?

1. $M_{OH^-} = 0.0065$ M

2. $M_{H^+} = 5.79 \times 10^{-10}$ M

3. $M_{H^+} = 1.27 \times 10^{-9}$ M

4. $M_{OH^-} = 1.77 \times 10^{-10}$ M **correct**

Explanation:

An acidic solution has an M_{H^+} greater than 1×10^{-7} M, and a M_{OH^-} less than 1×10^{-7} M.

002 4.0 points

According to Lewis acid-base theory, ammonia would be classified as a base because

1. It releases a hydroxide ion in water.
2. It donates a lone pair of electrons to form an N-H bond. CORRECT
3. The statement is incorrect; ammonia is an acid.
4. It accepts a lone pair of electrons to form an N-H bond.
5. It donates a proton to another molecule.
6. It accepts a proton from another molecule.

Explanation:

Lewis bases are lone pair (electron) donors.

003 4.0 points

Which of the following produces the STRONGEST conjugate base?

1. HCOOH ($\mathrm{p}K_\mathrm{a} = 3.75$)

2. HClO ($\mathrm{p}K_\mathrm{a} = 7.53$)

3. CH_3COOH ($\mathrm{p}K_\mathrm{a} = 4.75$)

4. HF ($\mathrm{p}K_\mathrm{a} = 3.45$)

5. HIO ($\mathrm{p}K_\mathrm{a} = 10.64$) **correct**

Explanation:

004 4.0 points

For the reaction

$$\mathrm{Br_2(g)} \rightleftharpoons 2\,\mathrm{Br(g)}$$

$\Delta G^\circ = +161.69$ kJ/mol at 25 °C. What is the value of K_p for this reaction?

1. 2.13×10^{28}

2. 5.46×10^{29}

3. 1.12×10^{-27}

4. 4.69×10^{-29} **correct**

5. 1.83×10^{-30}

6. 8.93×10^{26}

Explanation:

$\Delta G^\circ = -RT \ln K$
$K = \exp(-\Delta G^\circ/RT)$
$K = \exp(-161690/(8.314 \cdot 298.15))$
$K = 4.69 \times 10^{-29}$

005 4.0 points

Consider the famous ammonia preparation

$$3\,\mathrm{H_2(g)} + \mathrm{N_2(g)} \rightleftharpoons 2\,\mathrm{NH_3(g)}$$

The equation

$$K = \frac{[x]^2}{[0.1-3x]^3\,[0.7-x]}$$

is not a possible correct description of the equilibrium situation because

1. the 0.1 and 0.7 in the denominator are incompatible.

2. The equation is correct.

3. the denominator and numerator should be inverted.

4. $[0.7 - x]$ in the denominator should be $[0.7 - 3x]$.

5. $[x]$ in the numerator should be $[2x]$. **correct**

Explanation:

	$3\,H_2(g)$	$+$	$N_2(g)$	$\rightleftharpoons$	$2\,NH_3(g)$
ini, M	0.1		0.7		0
Δ, M	$-3x$		$-x$		$+2x$
eq, M	$0.1 - 3x$		$0.7 - x$		$2x$

$$K = \frac{[NH_3]^2}{[H_2]^3\,[N_2]} = \frac{(2x)^2}{(0.1 - 3x)^3\,(0.7 - x)}$$

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006 4.0 points

What is the pH of a solution labeled 0.0004 M NaOH?

1. 14.0

2. 10.6 **correct**

3. 13.4

4. 12.3

5. 9.5

Explanation:
$[NaOH] = 0.0004$ M

NaOH is a strong base which completely dissociates in aqueous solution:

$$NaOH \longrightarrow Na^+ + OH^-$$

$$[OH^-] = [NaOH] = 0.0004 \text{ M}$$

$$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{1 \times 10^{-14}}{0.0004} \text{ M} = 2.5 \times 10^{-11} \text{ M}$$

$$pH = -\log[H_3O^+] = 10.6021$$

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007 4.0 points

As a reaction proceeds to the equilibrium state at constant temperature, which of the following statements is correct?

1. The overall free energy of the system is decreasing until a minimum is reached. **correct**

2. The value of ΔG° is changing until it equals zero.

3. The value of K will change until it equals one.

4. The reaction will proceed such that the activities of the products equals the activities of the reactants.

5. The value of Q is changing and headed towards the minimum value possible.

Explanation:
As a reaction proceeds to equilibrium, Q changes until it equals K (not a minimum). K and ΔG° will NOT change during a reaction at constant temperature - they are set. Activities change until $Q = K$, not so they are all equal.
So the only true statement is about the system's free energy - which reaches a minimum value at equilibrium.

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008 4.0 points

The conjugate base of H_3PO_4 is:

1. HPO_4^{2-}

2. PO_4^{3-}

3. $H_2PO_4^-$ **correct**

4. OH^-

5. H_3O^+

6. H_2O

7. $H_4PO_4^+$

Explanation:

Remove one H^+ ion from a species to find its conjugate base.

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009 4.0 points

A 0.200 M solution of a weak monoprotic acid HA is found to have a pH of 3.00 at room temperature. What is the ionization constant of this acid?

1. 5.0×10^{-3}

2. 1.0×10^{-3}

3. 5.30

4. 1.8×10^{-5}

5. 2.0×10^{-5}

6. 5.0×10^{-6} **correct**

7. 1.0×10^{-6}

8. 2.0×10^{-9}

Explanation:

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010 4.0 points

At 600°C, the equilibrium constant for the reaction

$$2\,\mathrm{HgO(s)} \rightarrow 2\,\mathrm{Hg}(\ell) + \mathrm{O_2(g)}$$

is 2.8. Calculate the equilibrium constant for the reaction

$$\frac{1}{2}\,\mathrm{O_2(g)} + \mathrm{Hg}(\ell) \rightarrow \mathrm{HgO(s)}\,.$$

1. 1.7

2. 1.1

3. −1.7

4. 0.36

5. 0.60 **correct**

Explanation:

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011 4.0 points

Which of the following is true for strong acids?

1. Aqueous solutions of strong acids have a high pH.

2. They react only with weak bases.

3. After they lose a proton, they give rise to strong conjugate bases.

4. They are weak electrolytes.

5. They are totally ionized or dissociated in aqueous solutions. **correct**

6. They react only with strong bases.

Explanation:

The term ‘strong’ implies the species fully ionizes or dissociates; it does not imply any particular pH.

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012 4.0 points

Which of the following equations describes **any** sample of water with a neutral pH?

1. $[H^+] = 10^{-7}$

2. pH + pOH = 14

3. $[H^+] = [OH^-]$ **correct**

4. $[H^+][OH^-] = 10^{-14}$

5. pOH = 7

Explanation:

Water is considered neutral when $[H^+] = [OH^-]$.

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013 4.0 points

The equilibrium constant K_p for the reaction

$$\mathrm{I_2(g)} + \mathrm{Br_2(g)} \rightleftharpoons 2\,\mathrm{IBr(g)} + 11.7\,\mathrm{kJ}$$

is 280 at 150°C. Suppose that a quantity of IBr is placed in a closed reaction vessel and the system is allowed to come to equilibrium at 150°C. When equilibrium is established, the pressure of IBr is 0.200 atm. What is the pressure of I_2 at equilibrium?

1. None of these

2. 0.168 atm

3. 0.067 atm

4. 0.012 atm **correct**

5. 0.096 atm

Explanation:
At equilibrium,
$P_{\text{IBr}} = 0.200$ atm $\qquad K_\text{p} = 280$

$$\begin{array}{ccc} I_2(g) + & Br_2(g) \rightleftharpoons & 2\,IBr(g) + 11.7\text{ kJ} \\ 0 & 0 & y \\ x & x & -2x \\ \hline x & x & y-2x \end{array}$$

$$\begin{aligned} y - 2x &= 0.2 \\ K_\text{p} &= \frac{P^2_{\text{IBr}}}{P_{I_2} \cdot P_{Br_2}} = 280 \\ \frac{0.2^2}{x^2} &= 280 \\ x &= \frac{0.2}{\sqrt{280}} = 0.0119523 \\ P_{I_2} &= 0.0119523\text{ atm} \end{aligned}$$

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014 4.0 points

You have a weak molecular base with $K_\text{b} = 6.6 \times 10^{-9}$. What is the pH of a 0.0500 M solution of this weak base?

1. pH = 9.26 **correct**

2. pH = 7.12

3. pH = 4.74

4. None of these

5. pH = 3.63

Explanation:
[base] = 0.05 M

As mentioned, this is a weak base, so use the equation to calculate weak base $[OH^-]$ concentration:

$$\begin{aligned} [OH^-] &= \sqrt{K_\text{b}\, C_\text{b}} \\ &= \sqrt{(6.6 \times 10^{-9})\,(0.05)} \\ &= 1.81659 \times 10^{-5} \end{aligned}$$

After finding $[OH^-]$, you can find pH using either method below:
A)

$$\begin{aligned} \text{pOH} &= -\log\left(1.81659 \times 10^{-5}\right) = 4.74074 \\ \text{pH} &= 14 - 4.74074 = 9.25926 \end{aligned}$$

or B)

$$\begin{aligned} K_\text{w} &= [H^+][OH^-] = 1 \times 10^{-14} \\ [H^+] &= \frac{K_\text{w}}{[OH^-]} \\ &= \frac{1 \times 10^{-14}}{1.81659 \times 10^{-5}} = 5.50482 \times 10^{-10} \\ \text{pH} &= -\log\left(5.50482 \times 10^{-10}\right) = 9.25926 \end{aligned}$$

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015 4.0 points

The equilibrium constant K for the dissociation of $N_2O_4(g)$ to $NO_2(g)$ is 1700 at 500 K. Predict its value at 300 K. For this reaction, $\Delta H°$ is 56.8 kJ $\cdot$ mol^{-1}.

1. 1.54×10^7

2. 0.188 **correct**

3. 15.5

4. 1.11×10^{-4}

5. 1.32×10^{-6}

Explanation:

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016 4.0 points

Which of the following is a strong base?

1. $Al(OH)_3$

2. NH_4OH

3. KOH **correct**

4. $Fe(OH)_3$

Explanation:
Potassium hydroxide (KOH) is a strong base since it dissociates completely in water. The others, $Al(OH)_3$ (aluminum hydroxide), NH_4OH (ammonium hydroxide), and $Fe(OH)_3$ (iron(III) hydroxide) are weak bases since they do not dissociate completely in water.

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017 4.0 points

The reaction for the synthesis of ammonia

$$N_{2(g)} + 3\,H_{2(g)} \rightarrow 2\,NH_{3(g)}$$

is exothermic. Increasing the temperature applied to the system

I) increases the amount of NH_3.
II) decreases the amount of NH_3.
III) changes the value of K_{eq}.
IV) does not change the value of K_{eq}.

1. I and III only

2. II and III only **correct**

3. II and IV only

4. I and IV only

Explanation:

$$N_{2(g)} + 3\,H_{2(g)} \rightarrow 2\,NH_{3(g)} + \text{Heat}$$

Heat or energy is a product of this reaction. If temperature of the system is increased then the reaction will proceed in the reverse direction until equilibrium is re-established (decreasing NH_3). K_{eq} is temperature dependent so changing the temperature will change K_{eq}.

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018 4.0 points

For the reaction at equilibrium

$$A(aq) + B(aq) \rightleftharpoons AB(aq)$$

adding more A would change:

1. Both K and Q

2. Reversibility of the reaction

3. only K

4. Standard change in free energy (ΔG^o)

5. only Q **correct**

Explanation:
Adding more A would increase [A], and thus change the $Q = [AB]/([A][B])$ for the reaction. However, the reaction would shift right to maintain the equilibrium constant, K. The reversibility and standard change in free energy would not be affected.

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019 4.0 points

In the reaction,

$$HS^- + H_2O \rightarrow H_2S + OH^-,$$

HS^- acts as

1. a base. **correct**

2. an acid.

Explanation:
HS^- accepts H^+ to become H_2S. H_2O accepts H^+ to become H_3O^+.

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020 4.0 points

Which of the statements concerning equilibrium is NOT true?

1. Equilibrium in molecular systems is dynamic, with two opposing processes balancing one another.

2. A system moves spontaneously toward a state of equilibrium.

3. The equilibrium constant usually is independent of temperature. **correct**

4. A system that is disturbed from an equilibrium condition responds in a manner to restore equilibrium.

5. The value of the equilibrium constant for a given reaction is the same regardless of the direction from which equilibrium was attained.

Explanation:
Equilibrium constants are temperature dependent.

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021 4.0 points
At 1000 K the equilibrium pressure of the three gases in one mixture

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$$

were found to be 0.562 atm SO_2, 0.101 atm O_2, and 0.332 atm SO_3. Calculate the value of K_p for the reaction as written.

1. 5.83

2. 0.289

3. 0.171

4. 2.64

5. 3.46 **correct**

Explanation:
$P_{SO_3} = 0.332$ atm $P_{SO_2} = 0.562$ atm
$P_{O_2} = 0.101$ atm

$$K_p = \frac{P^2_{SO_3}}{P^2_{SO_2} \cdot P_{O_2}} = \frac{(0.332)^2}{(0.562)^2(0.101)} = 3.46$$

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022 4.0 points
What is the concentration of hydroxide ion in a 0.10 M solution of NaCN? The ionization constant of the weak acid HCN is 4.0×10^{-10}.

1. 1.6×10^{-9} M

2. 2.5×10^{-6} M

3. 6.3×10^{-6} M

4. 1.6×10^{-3} M **correct**

5. None of these

Explanation:

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023 4.0 points
The reaction shown below is allowed to reach equilibrium at 450 °C. At this temperature, the equilbrium constant K_c is equal to 4.0×10^{-2}.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Calculate the corresponding value for K_p for this reaction under the same conditions.

1. 4.2×10^{-1}

2. 2.4×10^{0} **correct**

3. 1.5×10^{0}

4. 6.7×10^{-4}

5. 9.8×10^{-1}

6. 5.2×10^{-2}

Explanation:
$R = 0.08206\ \mathrm{L \cdot atm/mol \cdot K}$
$T = 450°\mathrm{C} + 273.15 = 723.15$ K

$$\begin{aligned}\Delta n &= n_{\text{gas products}} - n_{\text{gas reactants}} \\ &= 2 - 1 = 1\end{aligned}$$

$$\begin{aligned}K_p &= K_c\,(R\,T)^{\Delta n} \\ &= (0.040)(0.08206)(723.15) \\ &= 2.37367 = 2.4 \times 10^0\end{aligned}$$

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024 4.0 points
Consider the following reaction that is at equilibrium:

$$2\,HCl(g) + I_2(s) \rightleftharpoons 2\,HI(g) + Cl_2(g)$$

What happens to the number of moles of HI(g) in the mixture when the total pressure of the system is increased by compression?

1. unable to determine

2. they increase

3. they decrease **correct**

4. they remain unchanged

Explanation:

Increasing the total pressure on the system by decreasing its volume (compression) will shift the equilibrium toward the side of the reaction with fewer numbers of moles of gaseous components. There are 2 moles of gas reactants (I_2 is a solid) and 3 moles of gas products - therefore compression favors the reactants which means the number of moles of HI are decreased.

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025 4.0 points

Using the law of mass action, write the equilibrium expression for the following reaction:

$$2\ Cu^{2+}(aq) + 4\ I^-(aq) \longleftrightarrow 2\ CuI(s) + I_2(aq)$$

1. $K = \frac{[I_2][CuI]^2}{[Cu^{2+}]^2[I^-]^4}$

2. $K = \frac{[Cu^{2+}]^2[I^-]^4}{[I_2][CuI]^2}$

3. $K = \frac{[I_2]}{[Cu^{2+}]^2[I^-]^4}$ **correct**

4. $K = \frac{[Cu^{2+}]^2[I^-]^4}{[I_2]}$

Explanation:

The equilibrium expression, K, is the ratio of products to reactants raised to their respective stoichiometric coefficients. Solid species are not included in the expression.