Recitation Worksheet Ten: Exam 3 Review

Name: | **MyID:**

Textbook:

Chemistry & Chemical Reactivity
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Instructions:

- This recitation worksheet is a review for Exam One.
- Exam coverage: 15.1-15.6, 18.5-18.7, and 16.1-16.3
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- The **recitation session during the exam week (October 28th– 31st) is still mandatory**. Your attendance will be recorded.
- A periodic table and formula sheet are attached to the end of this worksheet.

1. Write the equilibrium equation for the **reverse** reaction:

$$4\ CH_4\ (g) + 6\ O_2\ (g) \rightleftharpoons 4\ CO\ (g) + 8\ H_2O\ (g)$$

A. $K_c' = \dfrac{4\,[CO] + 8[H_2O]}{4\,[CH_4] + 6\,[O_2]}$

B. $K_c' = \dfrac{4\,[CO_4] + 6\,[O_2]}{4\,[CO] + 8\,[H_2O]}$

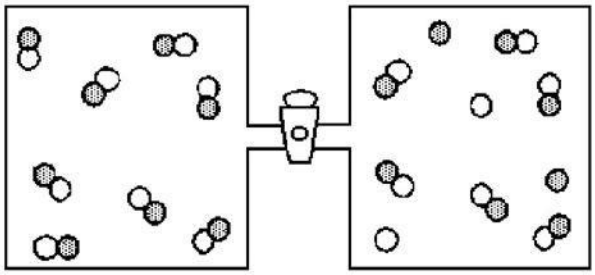
C. $K_c' = \dfrac{[CO]^4\,[H_2O]^8}{[CH_4]^4\,[O_2]^6}$

D. $K_c' = \dfrac{[CH_4]^4\,[O_2]^6}{[CO]^4\,[H_2O]^8}$

2. Determine the value of K_p for the following reaction if the equilibrium partial pressures are as follows: $P(CO_2)_{eq}$ =1.8 atm, $P(CO)_{eq}$ = 0.35 atm, $P(O_2)_{eq}$ = 0.50 atm. (Do not use scientific notation for your answer).

$$2\ CO_2(g) \rightleftharpoons 2\ CO(g) + O_2(g)$$

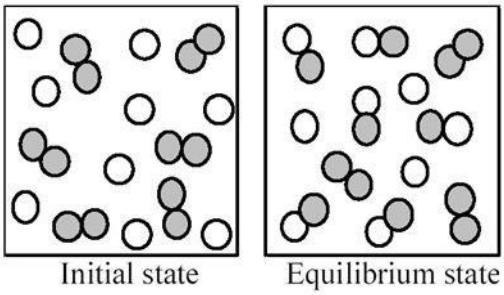
3. Consider the reaction A + B ⇌ 2 AB. The vessel on the right contains an equilibrium mixture of A atoms (shaded spheres), B atoms (unshaded spheres), and AB molecules.



If the barrier between the two vessels is removed and the contents of the two vessels are allowed to mix, what will be observed?

A. The reaction will go in the forward direction decreasing the number of A atoms and B atoms and increasing the number of AB molecules.
B. The reaction will go in the forward direction increasing the number of A atoms and B atoms and decreasing the number of AB molecules.
C. The reaction will go in the reverse direction decreasing the number of A atoms and B atoms and increasing the number of AB molecules.
D. The reaction will go in the reverse direction increasing the number of A atoms and B atoms and decreasing the number of AB molecules.

4. The following pictures represent the initial state and the equilibrium state for the gaseous state reaction of A_2 molecules (shaded spheres) with B atoms (unshaded spheres) to give AB molecules.



What is the best balanced chemical equation for the reaction?

A. $A_2 + B \rightleftharpoons A_2B$
B. $A_2 + 2\ B \rightleftharpoons A_2B_2$
C. $A_2 + 2\ B \rightleftharpoons 2\ AB$
D. $6\ A_2 + 9\ B \rightleftharpoons 3\ A_2 + 3B + 6\ AB$

5. At a certain temperature, bromine and nitric oxide react to form nitrosyl bromide:

$$Br_2(g) + 2\ NO(g) \rightleftharpoons 2\ NOBr(g)$$

When 0.010 mol Br_2 is mixed with 0.025 mol NO and 0.015 mol NOBr in a 2.50 L flask, the concentration of NOBr **decreases**. Which statement below is true?

A. $K_C < 36$
B. $K_C > 36$
C. $K_C < 90$
D. $K_C > 90$

6. Given:

$$2A(g) \leftrightharpoons B(g) + C(g) \qquad \Delta H^\circ = +27 \text{ kJ} \qquad K_c = 3.2 \times 10^{-4}$$

Which of the following would be true if the temperature were increased from 25 ˚C to 100 ˚C?

1. The value of K_c would be smaller.
2. The concentration of A(g) would be decreased.
3. The concentration of B(g) would increase.

A. 1 only
B. 2 only
C. 3 only
D. 1 and 2 only
E. 2 and 3 only

7. Gaseous hydrogen bromide decomposes at elevated temperatures according to the equation:

$$2\ HBr(g) \rightleftharpoons H_2(g) + Br_2(g).$$

At a certain temperature a 2.00 L flask is initially filled only with 0.600 mol of HBr. What is the value of K_C at that temperature if the flask contains 0.104 mol of H_2 at equilibrium?

A. 7.04×10^{-2}
B. 4.40×10^{-2}
C. 3.00×10^{-2}
D. 2.10×10^{-1}

8. A crude type of disappearing ink is based on the following endothermic equilibrium:

$$[Co(H_2O)_6]Cl_2(aq) \rightleftharpoons [CoCl_2(H_2O)_4](aq) + 2\ H_2O(l)$$
(colorless) (blue)

If the reactant solution is used to write on a piece of paper and the paper is allowed to partially dry, what can be done to bring out the colored handwriting?

A. add water
B. decrease the volume
C. put the paper in a freezer
D. put the paper in an oven

9. Consider the reaction:

$$N_2(g) + 3\ F_2(g) \rightarrow 2\ NF_3(g) \qquad \Delta H° = -253 \text{ kJ and } \Delta S° = -264 \text{ J/K at } 31\ °C$$

Calculate $\Delta G°$ and state whether the equilibrium composition should favor reactants or products at standard conditions.

A. $\Delta G° = -333$ kJ; the equilibrium composition should favor products.
B. $\Delta G° = -333$ kJ; the equilibrium composition should favor reactants.
C. $\Delta G° = -173$ kJ; the equilibrium composition should favor products.
D. $\Delta G° = -173$ kJ; the equilibrium composition should favor reactants.

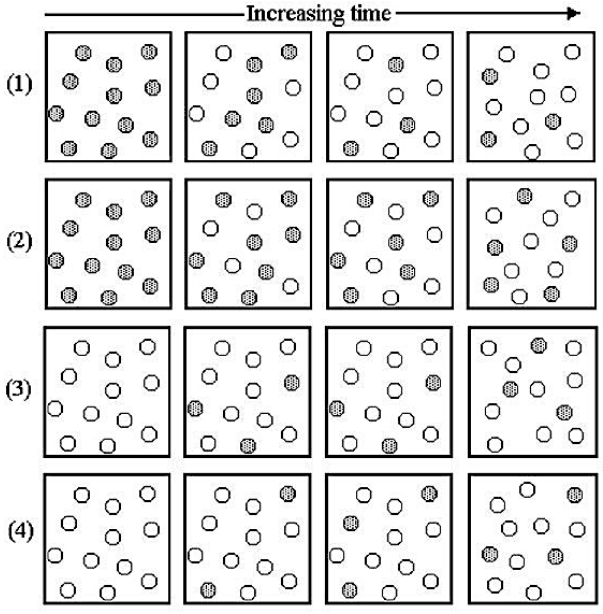
10. For the following reaction

$O_2(g) \rightleftharpoons 2\ O(g)$

what conditions favor production of oxygen atoms?

A. high temperature and low pressure
B. high temperature and high pressure
C. low temperature and low pressure
D. low temperature and high pressure

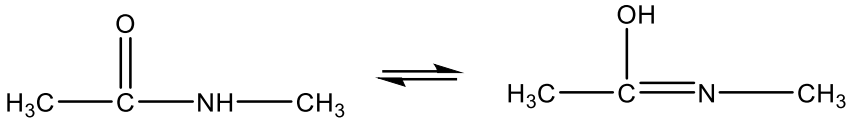
11. Consider the interconversion of A molecules (shaded spheres) and B molecules (unshaded spheres) according to the reaction A ⇌ B. Each of the series of pictures represents a separate experiment in which time increases from left to right.



Which of these experiments has resulted in an equilibrium state?

A. all of the experiments except experiment (1)
B. all of the experiments except experiment (2)
C. all of the experiments except experiment (3)
D. all of the experiments except experiment (4)

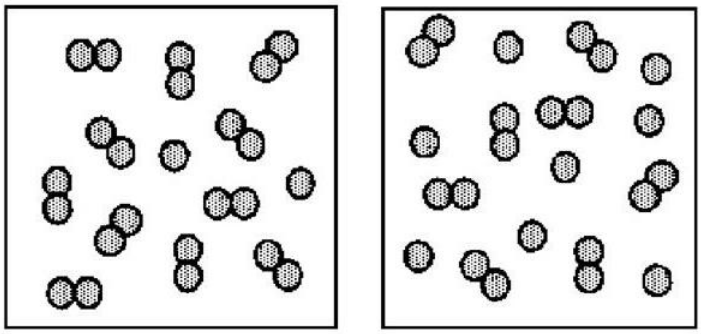
12. In solution, the two C_3H_7NO isomers exist in equilibrium:



If K_C = 0.57 at 31 °C and the initial concentration of the reactant is 0.50 M and the product is 0.70 M, what are the concentrations at equilibrium?

A. [reactant] = 0.43 M and [product] = 0.24 M
B. [reactant] = 0.67 M and [product] = 0.38 M
C. [reactant] = 0.76 M and [product] = 0.44 M
D. [reactant] = 0.82 M and [product] = 0.47 M

13. Consider the reaction $2A(g) \rightleftharpoons A_2(g)$. The pictures represent the initial state and the equilibrium state of the system.



Initial State Equilibrium State

For initial state 2 what is the relationship between the reaction quotient, Q_p, and the equilibrium constant, K_p?

A. $Q_p < K_p$
B. $Q_p = K_p = 1$
C. $Q_p = K_p \neq 1$
D. $Q_p > K_p$

14. At 2600 K, $\Delta G°$ = 775 kJ for the vaporization of boron carbide: $B_4C(s) \rightleftharpoons \_4\ B(g) + C(s)$. Find ΔG and determine if the process is spontaneous if the reaction vessel contains 4.00 mol $B_4C(s)$, 0.400 mol of $C(s)$, and $B(g)$ at a partial pressure of 1.00×10^{-5} atm. At this temperature, $R \times T$ = 21.6 kJ. Keep 3 significant figures.

[ ] kJ

15. For a reaction at constant temperature, as Q increases

[ ]
A. ΔG and $\Delta G°$ increase.
B. ΔG and $\Delta G°$ decrease.
C. ΔG increases, but $\Delta G°$ remains constant.
D. ΔG decreases, but $\Delta G°$ remains constant.

16. The following reaction is observed to have the provided partial pressures. Which condition best describes the state of the reaction.

$$\underset{2\text{ atm}}{2\ NO_2(g)} \rightleftharpoons \underset{1\text{ atm}}{N_2O_4(g)} \qquad K_P = 7.08$$

[ ]
A. The reaction is at equilibrium
B. The reaction is forming products faster than it is forming reactants
C. The reaction is forming reactants faster than it is forming products
D. The reaction is proceeding to the products rapidly
E. The reaction is proceeding to the reactants rapidly

17. The value for the equilibrium constant, K_c, is given for the following reactions:

$2\ NO(g) \rightleftharpoons N_2(g) + O_2(g)$ $\quad K_c = 2.1 \times 10^{30}$

$2\ NO(g) + Br_2(g) \rightleftharpoons 2\ NOBr(g)$ $\quad K_c = 1.96$

What is K_c for $N_2(g) + O_2(g) + Br_2(g) \rightleftharpoons 2\ NOBr(g)$ at 298 K?

[ ]

A. 9.7×10^{-16}

B. 2.1×10^{30}

C. 4.1×10^{30}

D. 9.3×10^{-31}

E. 8.7×10^{-61}

18. What is the value of K_p in **question 17** for $N_2(g) + O_2(g) + Br_2(g) \rightleftharpoons 2\ NOBr(g)$ at 298 K?

[ ]

19. What is the value of $\Delta G°$ in kJ/mol for the reaction $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$ at 545 K given the following concentrations: $[SO_2]_{eq} = 0.0911$ M, $[O_2]_{eq} = 0.0822$ M, $[SO_3]_{eq} = 0.0982$ M at 545 K?

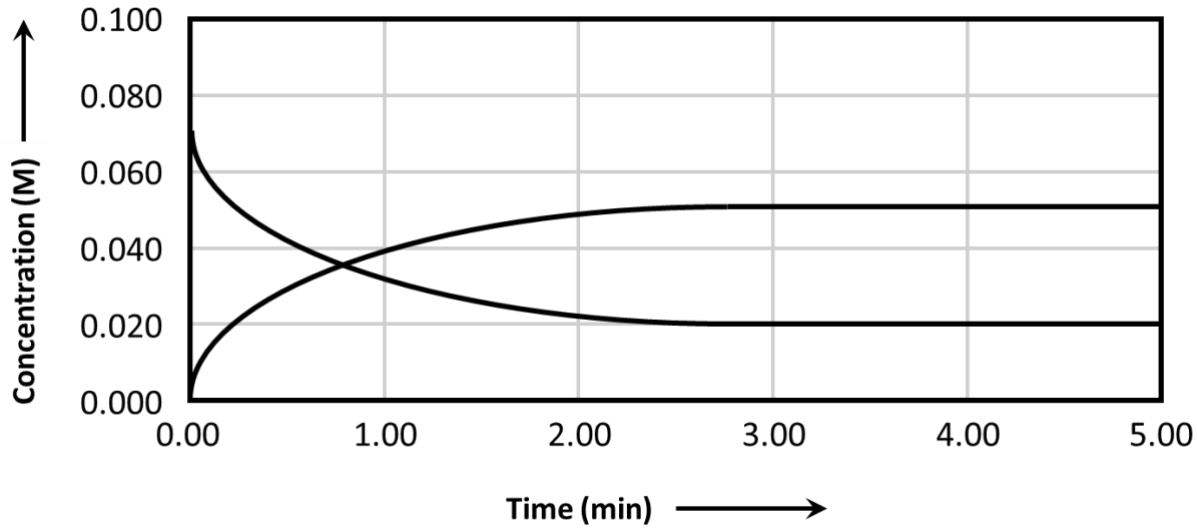
[ ] kJ

20. At equilibrium, a 1.0-liter container was found to contain 0.20 moles of A, 0.20 moles of B, 0.40 moles of C and 0.40 mole of D. If 0.10 moles of A and 0.10 moles of B are added to this system, what will be the new equilibrium concentration of A?

$$A_{(g)} + B_{(g)} \leftrightharpoons C_{(g)} + D_{(g)}$$

[ ] M

21. Shown below is a concentration vs. time plot for the reaction A ⇌ B. For this reaction the value of the equilibrium constant is



[ ]
A. $K_c < 1$.
B. $K_c = 0$.
C. $K_c = 1$.
D. $K_c > 1$.

22. Consider this reaction. At equilibrium, 6.00 mol of NO and 1.90 mol of O_2 are present at equilibrium in a 2.50 L flask. If the value for K_c is 23.8, how many moles of NO_2 are present?

$$2\ NO(g) + O_2(g) \rightleftharpoons 2\ NO_2(g)$$

[ ] mol

23. Consider the equilibrium system: $N_2O_4(g) \rightleftharpoons 2\ NO_2(g)$ for which $K_p = 0.1134$ at 25 °C and $\Delta H_r° = 58.03$ kJ/mol. Assume that 1 mole of N_2O_4 and 2 moles of NO_2 are introduced into a 5.0-liter container. Calculate the equilibrium value of $[N_2O_4]$?

[ ] M

24. Consider the equilibria:

$2\ SO_3(g) \leftrightharpoons 2\ SO_2(g) + O_2(g)$ $\quad K_c = 2.3 \times 10^{-7}$

$2\ NO_3(g) \leftrightharpoons 2\ NO_2(g) + O_2(g)$ $\quad K_c = 1.4 \times 10^{-3}$

Calculate the equilibrium constant for the reaction

$SO_2(g) + NO_3(g) \leftrightharpoons SO_3(g) + NO_2(g)$

[ ]

A. 78
B. 1.3×10^{-2}
C. 1.6×10^{-4}
D. 3.2×10^{-10}
E. 6.1×10^{3}

25. The equilibrium constant for the reaction ½ Cl2(g) + ½ F2(g) ⇌ ClF(g) is measured to be 9.3×10^{9} at 298 K and 3.3×10^{7} at 398 K. Calculate:

A. $\Delta G°_{rxn}$ at 298 K for the reaction in kJ/mol

[ ] kJ/mol

B. $\Delta H°$ between 298 K and 398 K

[ ] kJ/mol

26. Which of these pairs is **NOT** a Brønsted-Lowry conjugate acid-base pair?

A. HOBr and OBr^-
B. H_2SO_4 and SO_4^{2-}
C. $C_6H_5NH_3^+$ and $C_6H_5NH_2$
D. H_2CO_3 and HCO_3^-
E. $C_6H_5CH_2CO_2H$ and $C_6H_5CH_2CO_2^-$

27. For these three acids and their acid equilibrium constants, which of the statements are true? (Select all that apply.)

$HF(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$ $\quad K_a = 7.2 \times 10^{-4}$
$HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + PO_4^{3-}(aq)$ $\quad K_a = 3.6 \times 10^{-13}$
$CH_3CO_2H(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3CO_2^-(aq)$ $\quad K_a = 1.8 \times 10^{-5}$

A. HPO_4^{2-} is the strongest acid
B. HF produces the weakest conjugate base out of the three acids
C. The rate of dissociation of HF is the fastest as indicated by its acid equilibrium constant
D. The conjugate base of CH_3CO_2H is $CH_3CO_2^-$
E. HF is the strongest acid

28. You are given four solutions A, B, C, and D. Solution A has an $[H_3O^+] = 1.7 \times 10^{-4}$ M, solution B has a pH = 5.25, solution C has an $[OH^-] = 1.5 \times 10^{-5}$ and solution D has a pOH = 1.55. Arrange the solutions in the order of increasing $[H_3O^+]$.

A. A < B < C < D
B. D < C < B < A
C. C < B < A < D
D. B < A < D < C
E. A < B < D < C

29. A solution of a weak acid is prepared by dissolving 0.040 mol of HA in sufficient water to yield 2.0-L of solution. The pH of the solution was 3.53 at 25.0 °C. Calculate the K_a of HA.

A. 2.9×10^{-4}
B. 4.4×10^{-6}
C. 8.7×10^{-8}
D. 1.7×10^{-11}
E. 1.1×10^{-6}

30. What is the pH of a solution prepared by dissolving 1.50 g of $Ba(OH)_2$ (171.34 g/mol) in 3.00-L of water?

A. 2.23
B. 11.77
C. 11.47
D. 2.53
E. 13.70

31. Find the pH of a 0.135 M aqueous solution of a weak acid HA, for which $K_a = 2.3 \times 10^{-2}$.

A. 1.25
B. 3.28
C. 1.17
D. 1.34
E. 1.64

32. An aqueous solution of a weak base, trimethylamine, $(CH_3)_3N$, has a pH= 10.50. What will be the concentration of $(CH_3)_3N$ at equilibrium? $K_b = 6.3 \times 10^{-5}$.

$$(CH_3)_3N(aq) + H_2O(l) \rightleftharpoons (CH_3)_3NH^+(aq) + OH^-(aq)$$

33. What is the conjugate base of sulfuric acid?

A. HSO_4^-
B. H_3O^+
C. OH^-
D. SO_4^{2-}
E. $H_3SO_4^+$

34. What is the $[H_3O^+]$ for a solution at 25°C that has pOH = 5.640?

A. 2.34×10^{-4} M
B. 2.29×10^{-6} M
C. 4.37×10^{-9} M
D. 4.27×10^{-11} M
E. 8.360 M

35. The K_b of ethylamine is 4.30×10^{-4}. What is the pH of a 0.0847 M aqueous solution of ethylamine?

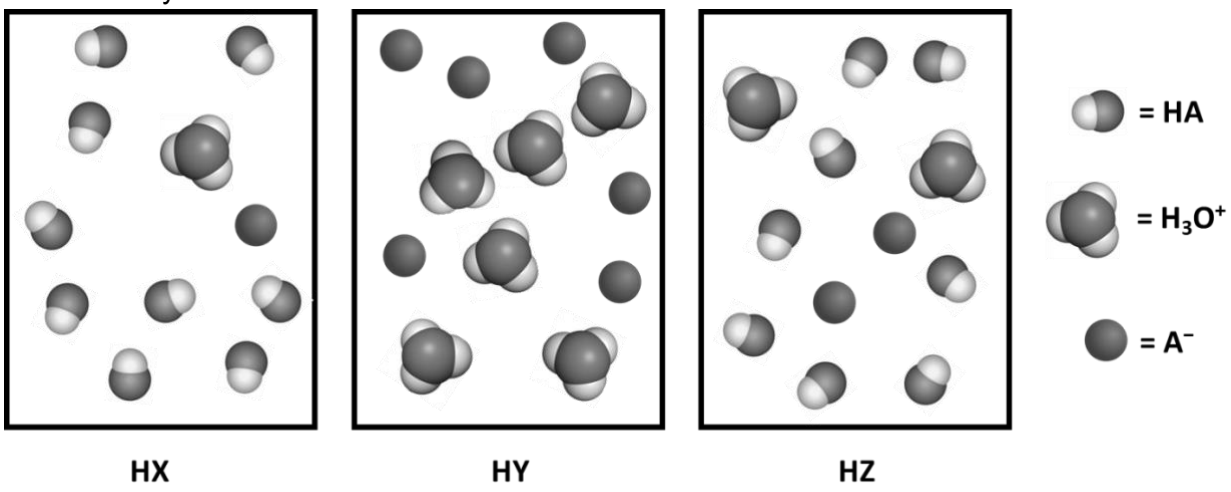
$$CH_3CH_2NH_2(aq) + H_2O(l) \leftrightharpoons CH_3CH_2NH_3^+(aq) + OH^-(aq)$$

36. Vinegar is a 5.0% solution by weight of acetic acid (CH_3CO_2H) (60.05 g/mol) in water. Given that $K_a = 1.8 \times 10^{-5}$ for acetic acid and assuming the density of vinegar to be 1.00 g/cm^3, what is the pH of this vinegar solution?

37. At 50 °C the value of K_w is 5.50×10^{-14}. A basic solution at 50 °C has

A. $[H_3O^+] < [OH^-] < 2.35 \times 10^{-7}$ M.
B. $[H_3O^+] < 2.35 \times 10^{-7}$ M $< [OH^-]$.
C. $[H_3O^+] = [OH^-] < 2.35 \times 10^{-7}$ M.
D. $[H_3O^+] > [OH^-] > 2.35 \times 10^{-7}$ M.

38. The pictures represent aqueous solutions of three acids HA (A = X, Y, or Z); water molecules have been omitted for clarity.



Which acid has the **smallest** value of K_a?

A. HX
B. HY
C. HZ
D. All have the same K_a value.

39. A monoprotic acid, Para-aminobenzoic acid (PABA), *p*-$H_2NC_6H_4(COOH)$, is used in some sunscreens and hair conditioning products. Calculate the pH of an aqueous solution with [PABA] = 0.030 M and $K_a = 2.2 \times 10^{-5}$.

A. 1.52
B. 3.09
C. 4.66
D. 6.18

40. Given the acids and their *K*a values:

Hydrocyanic acid, HCN $Ka = 4.00 \times 10^{-10}$

Phenol, C_6H_5OH $Ka = 1.00 \times 10^{-10}$

Benzoic acid, $C_6H_5CO_2H$ $Ka = 6.30 \times 10^{-5}$

What is the order of **increasing base strength** for CN^-, $C_6H_5O^-$, and $C_6H_5CO_2^-$?

A. $C_6H_5CO_2^- < C_6H_5O^- < CN^-$
B. $C_6H_5O^- < C_6H_5CO_2^- < CN^-$
C. $CN^- < C_6H_5CO_2^- < C_6H_5O^-$
D. $C_6H_5CO_2^- < CN^- < C_6H_5O^-$
E. $CN^- < C_6H_5O^- < C_6H_5CO_2^-$

41. Which of these species is amphoteric?

A. HPO_4^-
B. H_3O^+
C. PO_4^{3-}
D. Cl^-
E. None of the above are amphoteric

42. Given: $H_2O(l) + H_2O(l) \rightleftarrows H_3O^+(aq) + OH^-(aq)$, $\Delta H°rxn > 0$ When the temperature of a sample of pure water is raised above 25 °C,

A. the hydronium ion concentration will be greater than the hydroxide ion concentration.
B. the hydronium ion concentration will be less than the hydroxide ion concentration.
C. the value of K_w will increase.
D. the hydronium ion concentration could change to 1.0×10^{-10} M.
E. the hydroxide ion concentration could change to 1.0×10^{-10} M.

43. The magnitude of K_w indicates that _____.

A. water autoionizes very slowly
B. water autoionizes very quickly
C. water autoionizes only to a very small extent
D. the autoionization of water is exothermic

44. Which of the following acids has the lowest pH?

A. 0.1 M HA, $pK_a = 2.43$
B. 0.1 M HB, $pK_a = 4.55$
C. 0.1 M HC, $pK_a = 8.23$
D. 0.1 M HD, $pK_a = 11.89$

45. For which of the following solutions must the ionization of water be considered when calculating the pH or pOH? **Select all that apply.**

A. 3×10^{-8} M HNO_3
B. 0.10 g HCl in 1.0 L of solution
C. 0.00080 g NaOH in 0.50 L of solution
D. 1×10^{-7} M $Ca(OH)_2$

46. Phenylacetic acid ($C_6H_5CH_2COOH$, simplified here as HPAc) builds up in the blood of persons with phenylketonuria, an inherited disorder that, if untreated, causes mental retardation and death. A study of the acid shows that the pH of 0.12 M HPAc is 2.62. What is the pK_a of phenylacetic acid?