112-2 semester General Chemistry Midterm Exam (B) -20240417

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) At equilibrium, _____.
   A) all chemical reactions have ceased
   B) the rate constants of the forward and reverse reactions are equal
   C) the rates of the forward and reverse reactions are equal
   D) the value of the equilibrium constant is 1
   E) the limiting reagent has been consumed

   Answer: C

2) Which one of the following will change the value of an equilibrium constant?
   A) changing the volume of the reaction vessel
   B) adding other substances that do not react with any of the species involved in the equilibrium
   C) varying the initial concentrations of products
   D) varying the initial concentrations of reactants
   E) changing temperature

   Answer: E

3) The K_{eq} for the equilibrium below is 7.52×10^{-2} at 480.0 °C.

$$2Cl_2\,(g) + 2H_2O\,(g) \rightleftharpoons 4HCl\,(g) + O_2\,(g)$$

   What is the value of K_{eq} at this temperature for the following reaction?

$$2HCl\,(g) + \frac{1}{2}O_2\,(g) \rightleftharpoons Cl_2\,(g) + H_2O\,(g)$$

   A) 0.274 B) 3.65 C) 5.66×10^{-3} D) 13.3 E) -0.0376

   Answer: B

4) Given the following reaction at equilibrium, if $K_c = 1.90 \times 10^{19}$ at 25.0 °C, K_p = _____.

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

   A) 1.90×10^{19}
   B) 1.56×10^{4}
   C) 5.26×10^{-20}
   D) 6.44×10^{5}
   E) none of the above

   Answer: A

5) Which of the following expressions is the correct equilibrium-constant expression for the reaction below?

$$HF\,(aq) + H_2O\,(l) \rightleftharpoons H_3O^+\,(aq) + F^-\,(aq)$$

A) $[HF][H_2O] / [H_3O^+][F^-]$
B) $[F^-] / [HF]$
C) $[H_3O^+][F^-] / [HF]$
D) $1 / [HF]$
E) $[H_3O^+][F^-] / [HF][H_2O]$

Answer: C

6) Which of the following statements is true?
A) K_{eq} does not change with temperature, whereas Q is temperature dependent.
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 does not depend on the concentrations or partial pressures of reaction components.
E) Q does not change with temperature.

Answer: B

7) Which reaction will shift to the left in response to a decrease in volume?
A) $2\,SO_3\,(g) \rightleftharpoons 2\,SO_2\,(g) + O_2\,(g)$
B) $2HI\,(g) \rightleftharpoons H_2\,(g) + I_2\,(g)$
C) $4\,Fe\,(s) + 3\,O_2\,(g) \rightleftharpoons 2\,Fe_2O_3\,(s)$
D) $H_2\,(g) + Cl_2\,(g) \rightleftharpoons 2\,HCl\,(g)$
E) $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2\,NH_3\,(g)$

Answer: A

8) Consider the following reaction at equilibrium:

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

Le Châtelier's principle predicts that the moles of H_2 in the reaction container will increase with _____.
A) a decrease in the total pressure (T constant)
B) a decrease in the total volume of the reaction vessel (T constant)
C) some removal of NH_3 from the reaction vessel (V and T constant)
D) an increase in total pressure by the addition of helium gas (V and T constant)
E) addition of some N_2 to the reaction vessel (V and T constant)

Answer: A

9) Consider the following reaction at equilibrium:

$$2CO_2\,(g) \rightleftharpoons 2CO\,(g) + O_2\,(g) \qquad \Delta H° = -514\ kJ$$

Le Châtelier's principle predicts that a decrease in temperature will _____.

A) decrease the partial pressure of O_2 (g)
B) decrease the partial pressure of CO
C) decrease the value of the equilibrium constant
D) increase the value of the equilibrium constant
E) increase the partial pressure of CO_2 (g)

Answer: D

10) The effect of a catalyst on an equilibrium is to _____.

A) increase the equilibrium constant so that products are favored
B) slow the reverse reaction only
C) increase the rate at which equilibrium is achieved without changing the composition of the equilibrium mixture
D) increase the rate of the forward reaction only
E) shift the equilibrium to the right

Answer: C

11) Which one of the following is a Brønsted-Lowry acid?

A) CH_3COOH
B) HNO_2
C) HF
D) $(CH_3)_3NH^+$
E) all of the above

Answer: E

12) Which one of the following statements regarding K_w is <u>false</u>?

A) The value of K_w shows that water is a weak acid.
B) pK_w is 14.00 at 25 °C.
C) The value of K_w is always 1.0×10^{-14}.
D) K_w changes with temperature.
E) K_w is known as the ion product of water.

Answer: C

13) The hydride ion, H^-, is a stronger base than the hydroxide ion, OH^-. The product(s) of the reaction of hydride ion with water is/are _____.

A) H_2O_2 (aq)
B) OH^- (aq) + H_2 (g)
C) H_3O^+ (aq)
D) no reaction occurs
E) OH^- (aq) + $2H^+$ (aq)

Answer: B

14) The K_a of hypochlorous acid (HClO) is 3.0×10^{-8} at 25.0 °C. What is the percent ionization of hypochlorous acid in a 0.015 M aqueous solution of HClO at 25.0 °C?

A) 4.5×10^{-8} B) 14 C) 1.4×10^{-3} D) 2.1×10^{-5} E) 0.14

Answer: E

15) HA is a weak acid. Which equilibrium corresponds to the equilibrium constant K_b for A^-?

A) $HA\ (aq) + OH^-\ (aq) \rightleftharpoons H_2O\ (l) + H^+\ (aq)$

B) $HA\ (aq) + H_2O\ (l) \rightleftharpoons H_2A^+\ (aq) + OH^-(aq)$

C) $A^-\ (aq) + OH^-\ (aq) \rightleftharpoons HOA^{2-}\ (aq)$

D) $A^-\ (aq) + H_2O\ (l) \rightleftharpoons HA\ (aq) + OH^-\ (aq)$

E) $A^-\ (aq) + H_3O^+\ (aq) \rightleftharpoons HA\ (aq) + H_2O\ (l)$

Answer: D

16) Using the data in the table, which of the conjugate acids below is the strongest acid?

Base	K_b
ClO^-	3.3×10^{-7}
CO_3^{-2}	1.8×10^{-4}
HS^-	1.8×10^{-7}
NH_2CH_3	4.4×10^{-4}

A) HClO

B) H_2S

C) $NH_3CH_3^+$

D) HCO_3^-

E) H_2S and HClO

Answer: B

17) An aqueous solution of a particular compound has pH = 7.46. The compound is _____.

A) a strong acid B) a salt C) a strong base D) a weak acid E) a weak base

Answer: E

18) Of the compounds below, a 0.1 M aqueous solution of _____ will have the highest pH.

A) NaClO, K_a of HClO = 3.2×10^{-8}

B) NH_4NO_3, K_b of NH_3 = 1.8×10^{-5}

C) KCN, K_a of HCN = 4.0×10^{-10}

D) NaHS, K_b of HS^- = 1.8×10^{-7}

E) NaOAc, K_a of HOAc = 1.8×10^{-5}

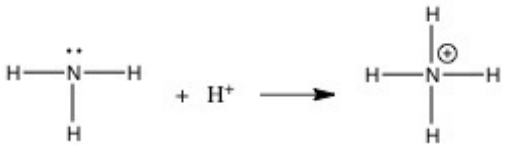
Answer: C

19) Of the following, which is the strongest acid?

A) $HClO_3$ B) $HClO_4$ C) $HClO_2$ D) HClO E) HIO

Answer: B

20) In the gas phase reaction below, NH_3 is acting as a(n) _____.



A) Lewis base
B) Lewis acid
C) Brønsted-Lowry base
D) Arrhenius acid
E) Brønsted-Lowry acid

Answer: A

21) Which one of the following pairs cannot be mixed together to form a buffer solution?
A) NaCl, HCl
B) RbOH, HF
C) H_2SO_3, $KHSO_3$
D) KOH, HNO_2
E) $HONH_2$, $HONH_3Cl$

Answer: A

22) What change will be caused by addition of a small amount of HCl to a solution containing fluoride ions and hydrogen fluoride?
A) The concentration of hydrogen fluoride will decrease and the concentration of fluoride ions will increase.
B) The concentration of fluoride ion will decrease and the concentration of hydrogen fluoride will increase.
C) The concentration of fluoride ions will increase as will the concentration of hydronium ions.
D) The concentration of hydronium ions will increase significantly.
E) The fluoride ions will precipitate out of solution as its acid salt.

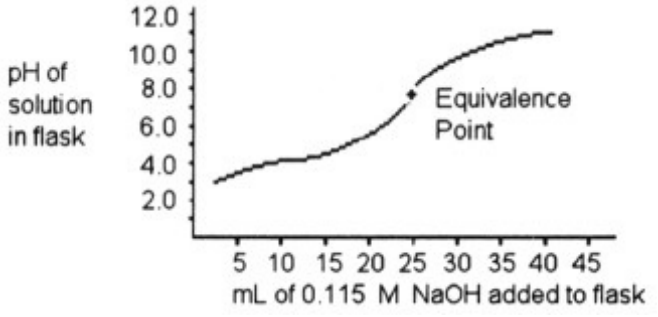
Answer: B

23) In a solution, when the concentrations of a weak acid and its conjugate base are equal, _____.
A) the buffering capacity is significantly decreased
B) the system is not at equilibrium
C) the -log of the $[H^+]$ and the -log of the K_a are equal
D) All of the above are true.

Answer: C

24) Which solution has the greatest buffering capacity?
A) 0.085 M NH_3 and 0.090 M NH_4Cl
B) 0.540 M NH_3 and 0.550 M NH_4Cl
C) 0.200 M NH_3 and 0.565 M NH_4Cl
D) 0.335 M NH_3 and 0.100 M NH_4Cl
E) They are all buffer solutions and would all have the same capacity.

Answer: B



25) A 50.0 mL sample of a solution of a monoprotic acid is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. The concentration of the monoprotic acid is about _____ mol/L.

A) 0.120 B) 0.0600 C) 0.240 D) 25.0 E) 0.100

Answer: B

Consider the following table of K_{sp} values.

Name	Formula	K_{sp}
Cadmium carbonate	$CdCO_3$	5.2×10^{-12}
Cadmium hydroxide	$Cd(OH)_2$	2.5×10^{-14}
Calcium fluoride	CaF_2	3.9×10^{-11}
Silver iodide	AgI	8.3×10^{-17}
Zinc carbonate	$ZnCO_3$	1.4×10^{-11}

26) Which compound listed below has the greatest molar solubility in water?

A) $Cd(OH)_2$ B) $ZnCO_3$ C) CaF_2 D) AgI E) $CdCO_3$

Answer: C

27) In which one of the following solutions is silver chloride the most soluble?

A) 0.200 M HCl
B) 0.0150 M NH_3
C) pure H_2O
D) 0.750 M $LiNO_3$
E) 0.185 M KCl

Answer: B

28) A result of the common-ion effect is _____.

A) that ions such as K^+ and Na^+ are common ions, so that their values in equilibrium constant expressions are always 1.00
B) that some ions, such as Na^+ (aq), frequently appear in solutions but do not participate in solubility equilibria
C) that common ions precipitate all counter-ions
D) that common ions, such as Na^+ (aq), don't affect equilibrium constants
E) that the selective precipitation of a metal ion, such as Ag^+, is promoted by the addition of an appropriate counterion (X^-) that produces a compound (AgX) with a very low solubility

Answer: E

29) Calculate the pH of a solution that is 0.278 M in sodium formate ($NaHCO_2$) and 0.222 M in formic acid (HCO_2H). The K_a of formic acid is 1.77×10^{-4}.

A) 10.16 B) 4.954 C) 3.647 D) 3.843 E) 13.90

Answer: D

30) When argon is placed in a container of neon, the argon spontaneously disperses throughout the neon because _____.

A) of the large attractive forces between argon and neon atoms
B) of solvent-solute interactions
C) the dispersion of argon atoms produces an increase in disorder
D) of hydrogen bonding
E) a decrease in energy occurs when the two mix

Answer: C

31) In a saturated solution of a salt in water, _____.

A) the rate of crystallization > the rate of dissolution
B) addition of more water causes massive crystallization
C) the rate of crystallization = the rate of dissolution
D) the rate of dissolution > the rate of crystallization
E) seed crystal addition may cause massive crystallization

Answer: C

32) The solubility of nitrogen gas at 25 °C and 101.325 kPa is 6.8×10^{-4} mol/L. If the partial pressure of nitrogen gas in air is 77.01 kPa, what is the concentration (molarity) of dissolved nitrogen?

A) 6.8×10^{-4} M B) 5.2×10^{-4} M C) 3.8×10^{-4} M D) 1.1×10^{-5} M E) 4.9×10^{-4} M

Answer: B

33) Which of the following statements is <u>false</u>?

A) Nonpolar liquids tend to be insoluble in polar liquids.
B) The solubility of gases in water decreases with increasing temperature.
C) The solubility of a gas increases in direct proportion to its partial pressure above the solution.
D) The weaker the attraction between the solute and solvent molecules, the greater the solubility.
E) Substances with similar intermolecular attractive forces tend to be soluble in one another.

Answer: D

34) Which one of the following concentration units varies with temperature?

A) molality
B) molarity
C) mass percent
D) mole fraction
E) all of the above

Answer: B

35) The magnitudes of K_f and of K_b depend on the identity of the _____.

A) solution
B) solute
C) solute and solvent
D) solvent
E) solvent and on temperature

Answer: D

36) Which of the following liquids will have the lowest freezing point?

A) pure H_2O

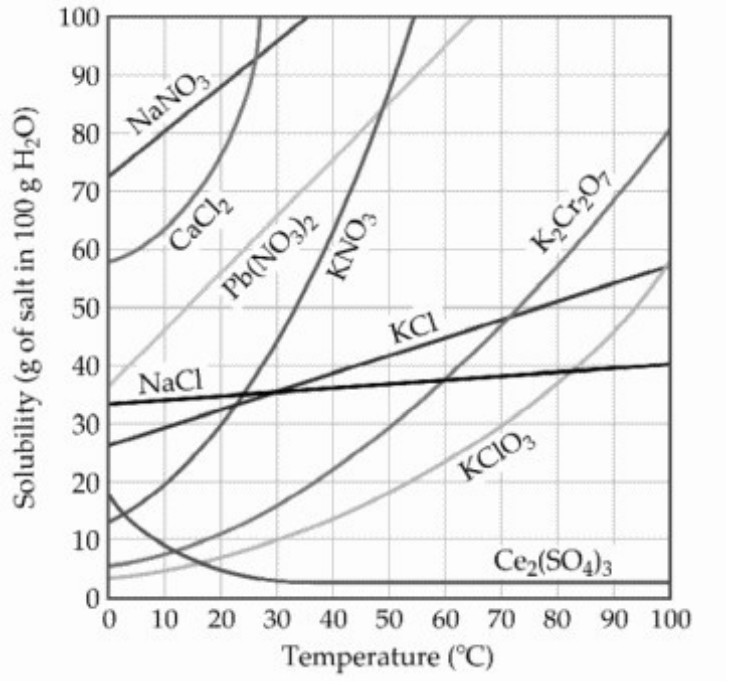
B) aqueous FeI_3 (0.24 m)

C) aqueous KF (0.50 m)

D) aqueous glucose (0.60 m)

E) aqueous sucrose (0.60 m)

Answer: C



37) A 81.5 g sample of calcium chloride is dissolved in 102 g of water at 45 °C (See the figure above). The solution is cooled to 20.0 °C and no precipitate is observed. This solution is _____.

A) hydrated

B) placated

C) saturated

D) unsaturated

E) supersaturated

Answer: E

38) Colligative properties of solutions include all of the following except _____.

A) depression of the freezing point of a solution upon addition of a solute to a solvent

B) the increase of reaction rates with increase in temperature

C) elevation of the boiling point of a solution upon addition of a solute to a solvent

D) depression of vapor pressure upon addition of a solute to a solvent

E) an increase in the osmotic pressure of a solution upon the addition of more solute

Answer: B

39) What is the molarity of a 7.00% by mass ammonium chloride aqueous solution at 20 °C? Density of the solution is 1.0198 g/mL.

A) 1.41 B) 0.146 C) 6.86 D) 1.33 E) 0.133

Answer: D

40) Under constant conditions, the half-life of a first-order reaction _____.

A) does not depend on the initial reactant concentration
B) can be calculated from the reaction rate constant
C) is constant
D) is the time necessary for the reactant concentration to drop to half its original value
E) All of the above are correct.

Answer: E

41) Which one of the following is <u>not</u> a valid expression for the rate of the reaction below?

$$4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$$

A) $\frac{1}{4}\frac{\Delta[NO_2]}{\Delta t}$

B) $\frac{1}{6}\frac{\Delta[H_2O]}{\Delta t}$

C) $-\frac{1}{4}\frac{\Delta[NH_3]}{\Delta t}$

D) $-\frac{1}{7}\frac{\Delta[O_2]}{\Delta t}$

E) All of the above are valid expressions of the reaction rate.

Answer: E

The data in the table below were obtained for the reaction:

$$A + B \rightarrow C$$

Experiment Number	[A] (M)	[B] (M)	Initial Rate (M/s)
1	0.451	0.885	1.13
2	0.451	1.77	1.13
3	1.35	0.885	10.17

42) (See the table above) The rate law for this reaction is rate = _____.

A) k[P] B) $k[A]^2$ C) $k[A]^2[B]^2$ D) k[A][B] E) $k[A]^2[B]$

Answer: B

43) The rate constant of a first-order process that has a half-life of 3.50 min is _____ s^{-1}.

A) 0.198 B) 1.65×10^{-2} C) 3.30×10^{-3} D) 1.98 E) 0.693

Answer: C

44) The rate of a reaction depends on _____.

A) collision energy
B) collision orientation
C) collision frequency
D) all of the above
E) none of the above

Answer: D

45) In the Arrhenius equation,

$$k = Ae^{-Ea/RT}$$

_____ is the frequency factor.

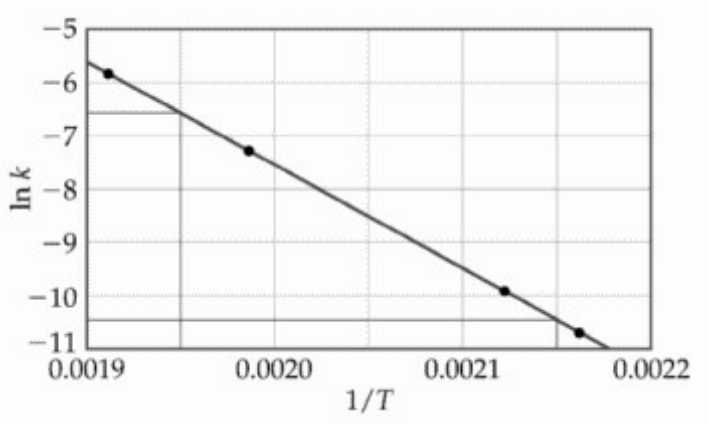
A) E_a B) A C) k D) e E) R

Answer: B

46) The decomposition of [A] in solution at 80 °C proceeds via the following reaction:

$$A\ (aq) \rightarrow B\ (aq)$$

The dependence of the rate constant on temperature is studied and the graph below is prepared from the results.



What is the energy of activation (kJ/mol) for this reaction?

A) 4.4×10^{-7} B) 4.4×10^{-4} C) 1.6×10^{5} D) 1.9×10^{4} E) 160

Answer: E

47) For the elementary reaction

$$NO_3 + CO \rightarrow NO_2 + CO_2$$

the molecularity of the reaction is _____, and the rate law is rate = _____.

A) 2, $k[NO_2][CO_2]$

B) 2, $k[NO_3][CO]/[NO_2][CO_2]$

C) 4, $k[NO_3][CO][NO_2][CO_2]$

D) 2, $k[NO_3][CO]$

E) 4, $k[NO_2][CO_2]/[NO_3][CO]$

Answer: D

48) A possible mechanism for the overall reaction

$$Br_2\,(g) + 2NO\,(g) \rightarrow 2NOBr\,(g)$$

is

$$\text{Step 1) } NO\,(g) + Br_2\,(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} NOBr_2\,(g) \text{ (fast)}$$

$$\text{Step 2) } NOBr_2\,(g) + NO\,(g) \xrightarrow{k_2} 2NOBr \text{ (slow)}$$

What is the rate determining step for this reaction?

A) step 1
B) step 2
C) reverse of step 2
D) reverse of step 1
E) both steps 1 and 2

Answer: B

49) A catalyst can _____ the rate of a reaction by providing an alternative pathway with a _____ activation energy

A) increase, lower
B) decrease, constant
C) increase, higher
D) decrease, lower
E) decrease, higher

Answer: A

50) The rate of disappearance of HBr in the gas phase reaction

$$2HBr\,(g) \rightarrow H_2\,(g) + Br_2\,(g)$$

is 0.190 M s^{-1} at 150 °C. The rate of appearance of Br_2 is _____ M s^{-1}.

A) 0.095 B) 0.0361 C) 2.63 D) 0.380 E) 0.436

Answer: A