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

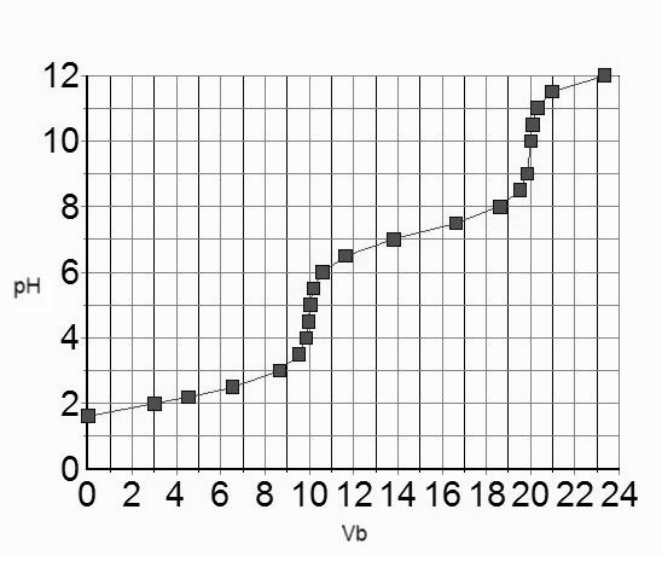
1) In the titration of 50.0 mL of 0.0200 M $C_6H_5COOH(aq)$ with 0.100 M NaOH(aq), what is/are the major species in the solution after the addition of 5.0 mL of NaOH(aq)?

A) C_6H_5COOH, $C_6H_5COO^-$, and Na^+ B) C_6H_5COOH

C) C_6H_5COOH, OH^-, and Na^+ D) $C_6H_5COO^-$ and Na^+

Answer: A

2) The titration curve for 10.0 mL of 0.100 M $H_3PO_4(aq)$ with 0.100 M NaOH(aq) is given below.



Estimate the pK_{a2} of H_3PO_4.

A) 2.2 B) 7.2 C) 4.8 D) 9.8

Answer: B

3) Ten milliliters of 0.10 M $NH_3(aq)$ ($K = 1.8 \times 10^{-5}$) is mixed with 10 mL of 0.10 M NH_4Cl. Neglecting the differences between activities and concentrations, the resulting solution:

A) has a pH = 4.74

B) has a $[H^+]$ of approximately 10^{-3} M

C) has an $[OH^-]$ of 1.8×10^{-5} M

D) has a $[NH_4^+]$ greater than that of the $NH_4Cl(aq)$

E) is acidic

Answer: C

4) Twenty-five milliliters of 0.10 M HCl is titrated with 0.10 M NaOH. What is the pH when 30 ml of NaOH have been added?

A) 1.8 B) 2.0 C) 12.3 D) 12.2 E) 12.0

Answer: E

5) 1.80 grams of an impure mixture containing sodium carbonate required 84.0 ml of 0.125 M H_2SO_4 for complete neutralization. What percent of the mixture is sodium carbonate?

A) 120% B) 62% C) 1.1% D) 57% E) 31%

Answer: B

6) Determine the pH of the following solution. Initial concentrations are given.

$[NH_3] = 1.20$ M, $[KOH] = 0.320$ M, $K_b\ (NH_3) = 1.8 \times 10^{-5}$

A) 13.5 B) 12.2 C) 9.8 D) 11.7 E) 8.7

Answer: A

7) For the following titration, determine whether the solution at the equivalence point is acidic, basic, or neutral and why: $NaHCO_3$(aq) titrated with NaOH(aq)

A) basic because of excess OH^-

B) basic because of hydrolysis of CO_3^{2-}

C) acidic because of hydrolysis of HCO_3^-

D) acidic because of hydrolysis of Na^+

E) neutral salt of strong acid and strong base

Answer: B

8) What is the $[H_3O^+]$ of a solution measured to be 0.20 M in sodium acetate and 0.40 M in acetic acid? [$K_a = 1.8 \times 10^{-5}$]

A) 3.6×10^{-5} M B) 4.7 M C) 7.2×10^{-5} M D) 9.0×10^{-6} M E) 1.8×10^{-5} M

Answer: A

9) What is the pH of a solution made by dissolving 2.16 g of sodium benzoate ($NaC_6H_5CO_2$) in a sufficient volume of 0.033 M benzoic acid solution to prepare 500.0 mL of buffer? [K_a for benzoic acid is 6.3×10^{-5}]

A) 5.77 B) 4.16 C) 4.64 D) 6.30 E) 4.37

Answer: B

10) What volume in ml of 0.05 M NaOH would have to be added to 50.0 ml of 0.10 M H_2SO_4 in order to affect complete neutralization of the acid?

A) 20 mL B) 200 mL C) 150 mL D) 50 mL E) 100 mL

Answer: B

11) Determine the $[F^-]$ of the following solution. Initial concentrations are given.

$[HF] = 1.296$ M, $[NaF] = 1.045$ M, K_a for HF is 6.6×10^{-4}

A) 0.251 M B) 1.046 M C) 2.344 M D) 8.2×10^{-4} M E) 5.3×10^{-4} M

Answer: B

12) 25 ml of 0.10 M acetic acid is titrated with 0.10 M NaOH. What is the pH before any NaOH is added? K_a for acetic acid = 1.8×10^{-5}.

A) 5.7 B) 2.2 C) 2.9 D) 4.3 E) 1.0

Answer: C

13) What is the pH of a 0.30 M trisodium phosphate solution? [K_a for monohydrogen phosphate ion is 4.2×10^{-13}]

A) 12.9 B) 10.5 C) 13.3 D) 8.6 E) 9.8

Answer: A

14) If some NH_4Cl is added to an aqueous solution of NH_3:
A) the pH of the solution will decrease
B) NH_4Cl cannot be added to NH_3
C) the solution will not have pH
D) the pH of the solution will increase
E) the pH of the solution will not change
Answer: A

15) If 25 mL of 0.20 M NaOH is added to 50 mL of 0.10 M $HC_2H_3O_2$ ($K_a = 1.8 \times 10^{-5}$), what is the pH?
A) 5.33 B) 10.21 C) 1.34 D) 13.56 E) 8.78
Answer: E

16) A solution contains $[Ba^{2+}] = 5.0 \times 10^{-5}$ M, $[Ag^+] = 3.0 \times 10^{-5}$ M, and $[Zn^{2+}] = 2.0 \times 10^{-7}$ M. Sodium oxalate is slowly added so that $[C_2O_4^{2-}]$ increases.

Salt	BaC_2O_4	ZnC_2O_4	$Ag_2C_2O_4$
K_{sp}	1.5×10^{-8}	1.35×10^{-9}	1.1×10^{-11}

What is the concentration of the first cation to precipitate when the second cation just begins to precipitate?
A) 5.0×10^{-5} B) 1.35×10^{-9} C) 2.2×10^{-6} D) 1.1×10^{-11} E) 1.3×10^{-6}
Answer: C

17) What is the minimum concentration of CN^- that will prevent the precipitation of AgX(s) from a solution that is 0.149 M in X^-(aq) and 0.0184 M in Ag^+(aq)? (K_{sp} for AgX(s) = 5.2×10^{-17}; K_f for $Ag(CN)_2^-$ = 5.6×10^{18})
A) 9.4×10^{-6} M
B) 3.1×10^{-3} M
C) 1.8×10^{-10} M
D) 9.6×10^{-3} M
E) 1.2×10^{-3} M
Answer: B

18) What is the molar solubility of barium carbonate in pure water? ($K_{sp} = 5.1 \times 10^{-9}$)
A) 7.1×10^{-5} M
B) 5.1×10^{-9} M
C) 1.1×10^{-3}
D) 2.6×10^{-17}
E) 1.7×10^{-3}
Answer: A

19) What is the molar solubility of PbI_2 ($K_{sp} = 7.1 \times 10^{-9}$) in 0.10 M $Pb(NO_3)_2$?
A) 2.6×10^{-3} M
B) 7.1×10^{-8} M
C) 2.7×10^{-5} M
D) 1.3×10^{-4} M
E) 2.7×10^{-4} M
Answer: D

20) The solubility product constant of silver bromide is 5.0×10^{-13}. What is the molar solubility of this compound?

A) $(50)^{1/2} \times 10^{-6}$

B) $(50)^{1/2} \times 10^{-7}$

C) $(5.0/2)^{1/2} \times 10^{-7}$

D) 5.0×10^{-13}

E) $(5.0 \times 10^{-13})^2$

Answer: B

21) The solubility product constant of $Mg(OH)_2$ is 9.0×10^{-12}. If a solution is 0.010 M with respect to Mg^{2+} ion, the amount of $[OH^-]$ required to start the precipitation of $Mg(OH)_2$ is:

A) 3.0×10^{-7} M

B) 1.5×10^{-5} M

C) 9.0×10^{-10}

D) 3.0×10^{-5} M

E) 1.5×10^{-7}

Answer: D

22) The solubility of magnesium fluoride in water at 18 °C is tabulated as 0.0076 g per 100 mL. What is the solubility product for this salt?

A) 6.8×10^{-7} B) 8.0×10^{-8} C) 3.8×10^{-10} D) 7.3×10^{-9} E) 7.6×10^{-6}

Answer: D

23) What ratio of $[NH_4^+]/[NH_3]$ would provide a buffer of pH low enough to avoid precipitation of $Co(OH)_2$ [$K_{sp} = 2.0 \times 10^{-14}$] from a 0.50 M Co^{2+} solution? [K_b for $NH_3 = 1.8 \times 10^{-5}$]

A) 50/1 B) 1/1 C) 90/1 D) 1/90 E) 1/50

Answer: C

24) When 100 mL each of 2.0×10^{-4} M Ca^{2+} and 2.0×10^{-2} M F^- are mixed, what is the remaining Ca^{2+} ion concentration and is precipitation complete? The solubility product constant of CaF_2 is 5.3×10^{-9}.

A) 5.6×10^{-4}, no

B) 1.7×10^{-6}, yes

C) 1.7×10^{-8}, yes

D) 5.4×10^{-5}, no

E) 4.3×10^{-7}, no

Answer: D

25) What is the free Ag^+ concentration of 0.020 M Ag^+ solution mixed with an equal volume of 2.0 M NH_3? K_f for $[Ag(NH_3)_2]^+$ is 1.6×10^7.

A) 6.5×10^{-10} B) 6.3×10^{-8} C) 2.0×10^{-14} D) 3.1×10^{-10} E) 1.3×10^{-10}

Answer: A

26) A saturated solution of silver chromate has a concentration of 7.4×10^{-5} M. What is the K_{sp} of this compound?

A) $3(7.4 \times 10^{-5})^3$

B) $(7.4 \times 10^{-5})^3$

C) $4(7.4 \times 10^{-5})^3$

D) 7.4×10^{-5}

E) $(7.4 \times 10^{-5})^2$

Answer: C

27) Write the solubility product constant for $KAl(SO_4)_2(s)$?

A) $([K^+] \times [Al^{3+}] \times 2[SO_4^{2-}]/[KAl(SO_4)_2])$

B) $([K^+] \times [Al^{3+}] \times [SO_4^{2-}])$

C) $([K^+] \times [Al^{3+}] \times [SO_4^{2-}]/[KAl(SO_4)_2])$

D) $([K^+] \times [Al^{3+}] \times [SO_4^{2-}]^2)$

E) none of these

Answer: D

28) The K_{sp} of AgCl is 1.7×10^{-10}. How many moles of $MnCl_2$ can be dissolved in one liter of a solution in which $[AgNO_3] = 3.4 \times 10^{-4}$ M before a precipitate appears?

A) 2.5×10^{-7} mol

B) 5.0×10^{-7} mol

C) 2.4×10^{-7} mol

D) 2.0×10^{6} mol

E) 5.8×10^{-14} mol

Answer: A

29) What is the concentration of Ca^{2+} in ppm (mg/L) in cave water saturated with calcite (calcium carbonate, $K_{sp} = 4.7 \times 10^{-9}$)?

A) 7.5 B) 6.9 C) 5.0 D) 2.7 E) 3.8

Answer: D

30) A swimming pool was sufficiently alkaline so that the carbon dioxide absorbed from the air produced a solution in the pool that was 2×10^{-4} M in carbonate ion. If the pool originally contained 4×10^{-3} M Mg^{2+}, 6×10^{-4} M Ca^{2+}, and 8×10^{-7} M Fe^{2+}, then the precipitate that was formed consisted of _____.
[K_{sp} values are: $CaCO_3$, 4.7×10^{-9}; $MgCO_3$, 4.0×10^{-5}; $FeCO_3$, 2.0×10^{-11}]

A) only $CaCO_3$ and $FeCO_3$

B) $MgCO_3$, $CaCO_3$, and $FeCO_3$

C) only $CaCO_3$

D) only $FeCO_3$

E) only $MgCO_3$

Answer: A

31) Consider the reaction:

	$N_2(g)$	+ 3 $X_2(g)$	→ 2 $NX_3(g)$
$\Delta H°$	0.0	0.0	-43 kJ/mol
$S°$	192	210	172 J/mol-K

What is $\Delta G°$ for this reaction at 591 K? Is the reaction spontaneous at 591 K?

A) 196 kJ/mol, yes
B) -239 kJ/mol, no
C) -196 kJ/mol, no
D) 239 kJ/mol, yes
E) 196 kJ/mol, no

Answer: E

32) What is $\Delta G°_{rxn}$?

		2 $O_3(g)$	→ 3 $O_2(g)$
$\Delta G_f°$	(J/mol K)	163.2	0

A) -326.4 kJ B) -163.2 kJ C) 326.2 kJ D) 54.4 kJ E) 163.2 kJ

Answer: A

33) For the reaction $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$ at 298 K, $K_{eq} = 1.87 \times 10^{-7}$, $\Delta S° = 181.92$ J/mol K, what is K_{eq} at 200 K if $\Delta H° = 92.6$ kJ/mol?

A) 16.8 B) 1.87×10^{-7} C) 2.08×10^{-15} D) 5.35×10^{6} E) 5.95×10^{-2}

Answer: C

34) Calculate the temperature for which K_{eq} for a reaction is 1.04×10^{3} where $\Delta H° = -83.2$ kJ/mol and $\Delta S° = -246$ J/mol · K.

A) 307 K
B) 0.274 K
C) 274 K
D) 0.307 K
E) cannot be determined without $\Delta G°$

Answer: C

35) For the reaction, $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

$S°$ (J/mol K)	88.70	39.75	213.6

what is $\Delta S°_{rxn}$?

A) 85.1 J/mol · K
B) -85.1 J/mol · K
C) 262.5 J/mol · K
D) -164.7 J/mol · K
E) 164.7 J/mol · K

Answer: E

36) The Gibbs energy change for a reaction is -298 kJ. The reaction is therefore:

A) endothermic
B) irreversible
C) exothermic
D) spontaneous
E) nonspontaneous

Answer: D

37) Calculate the entropy change for methanol at its normal boiling point of 64.5°C. $\Delta H°$ = 38.0 kJ/mol.

A) 0.589 kJ/mol · K
B) 0.112 kJ/mol · K
C) 112 kJ/mol · K
D) 589 kJ/mol · K
E) 0.589×10^{-2} kJ/mol · K

Answer: B

38) Consider the reaction: $N_2O_4(g) \rightarrow 2\ NO_2(g)$

K_{eq} = 0.1134 at 20 °C. $\Delta H°_{rxn}$ = 58.03 kJ/mol

What is $\Delta G°$ for this reaction at 20 °C?

A) 4.9 kJ B) 5.4 kJ C) 0.36 kJ D) -5.4 kJ E) 5.3 kJ

Answer: E

39) For the reaction, $N_2O_4(g) \rightarrow 2\ NO_2(g)$

$S°$ (J/mol K)	304.2	240.0

what is $\Delta S°_{rxn}$?

A) -175.8 J/mol · K
B) -64.2 J/mol · K
C) 544.2 J/mol · K
D) 175.8 J/mol · K
E) 64.2 J/mol · K

Answer: D

40) Consider the following reaction:

$$4\ NH_3(g) + 7\ O_2(g) \rightarrow 4\ NO_2(g) + 6\ H_2O\ (l)$$

$\Delta G°_f$	-16.7	0.0	51.8	-237.2 kJ/mol

What is K_{eq} for this reaction at 25 °C?

A) e^{464} B) 1.59 C) 252 D) 0.63 E) e^{-464}

Answer: A

41) Consider the following reaction:

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$$

$S°$	192.51	186.69	94.56 J/mol·deg

What is $\Delta S°$ for this reaction in J/mol·deg?

A) -92.3 J/mol·deg
B) 284.6 J/mol·deg
C) 92.3 J/mol·deg
D) -284.6 J/mol·deg
E) 94.6 J/mol·deg

Answer: D

42) Which of the following has the largest molar entropy?

A) $H_2(g)$ B) $I_2(g)$ C) Xe(g) D) He(g)

Answer: B

43) Which of the following substances under equal conditions and in the same phase has the greatest molar entropy?

A) N_2O_3 B) NO C) NO_2 D) N_2O_5 E) N_2O_4

Answer: D

44) What is $\Delta G°$ at 25°C?

$CO(g) + 2\ H_2(g) \rightarrow CH_3OH(g)$ $\Delta H° = -90.7$ kJ $\Delta S° = -221$ J/K

A) -90.9 kJ B) -85.2 kJ C) -24.8 kJ D) -156.6 kJ E) -96.2 kJ

Answer: C

45) For the reaction,

$2\ O_3(g) \rightarrow 3\ O_2(g)$

$S°$ (J/mol K)	238.8	205.0

what is $\Delta S°_{rxn}$?

A) 137.4 J/mol K
B) 171.2 J/mol K
C) -33.8 J/mol K
D) -137.4 J/mol K
E) 33.8 J/mol K

Answer: A

46) Predict whether ΔS is positive or negative for the following process:

$H_2O(g) \rightarrow H_2O(s)$

A) negative
B) positive
C) There is not enough information to determine.
D) ΔS changes the same on both sides of the equation.
E) ΔS doesn't change.

Answer: A

47) For $Cl_2O(g) + 3/2\ O_2(g) \rightarrow 2\ ClO_2$ $\Delta H° = 126$ kJ/mol, and $\Delta S° = -74.9$ J/mol-deg at 377 °C. What is $\Delta G°$ in kJ/mol?

A) 98.3 B) 129.2 C) 51.4 D) 77.8 E) 175

Answer: E

48) The reaction A + B → C + D is second order in A and zero order in B. The value of k is 0.012 $M^{-1}\ min^{-1}$. What is the rate of this reaction when [A] = 0.125 M and [B] = 0.435 M?

A) 1.5×10^{-3} M min^{-1}
B) 1.9×10^{-4} M min^{-1}
C) 5×10^{-4} M min^{-1}
D) 3.4×10^{-3} M min^{-1}
E) 1.3 M min^{-1}

Answer: B

49) Choose the INCORRECT answer. The rate of a chemical reaction:

A) usually is increased when the concentration of one of the reactants is increased
B) is dependent on temperature
C) will be very rapid if the activation energy is large
D) describes the change in concentration of a reactant or product with time
E) may be increased by certain catalytic agents

Answer: C

50) In the first order reaction A → products, [A] = 0.400 M initially and 0.250 M after 15.0 min, what will [A] be after 175 min?

A) 1.67×10^{-3} M
B) 6.024×10^{-3} M
C) 3.70×10^{-2} M
D) 2.31×10^{-1} M
E) 1.04×10^{-3} M

Answer: A