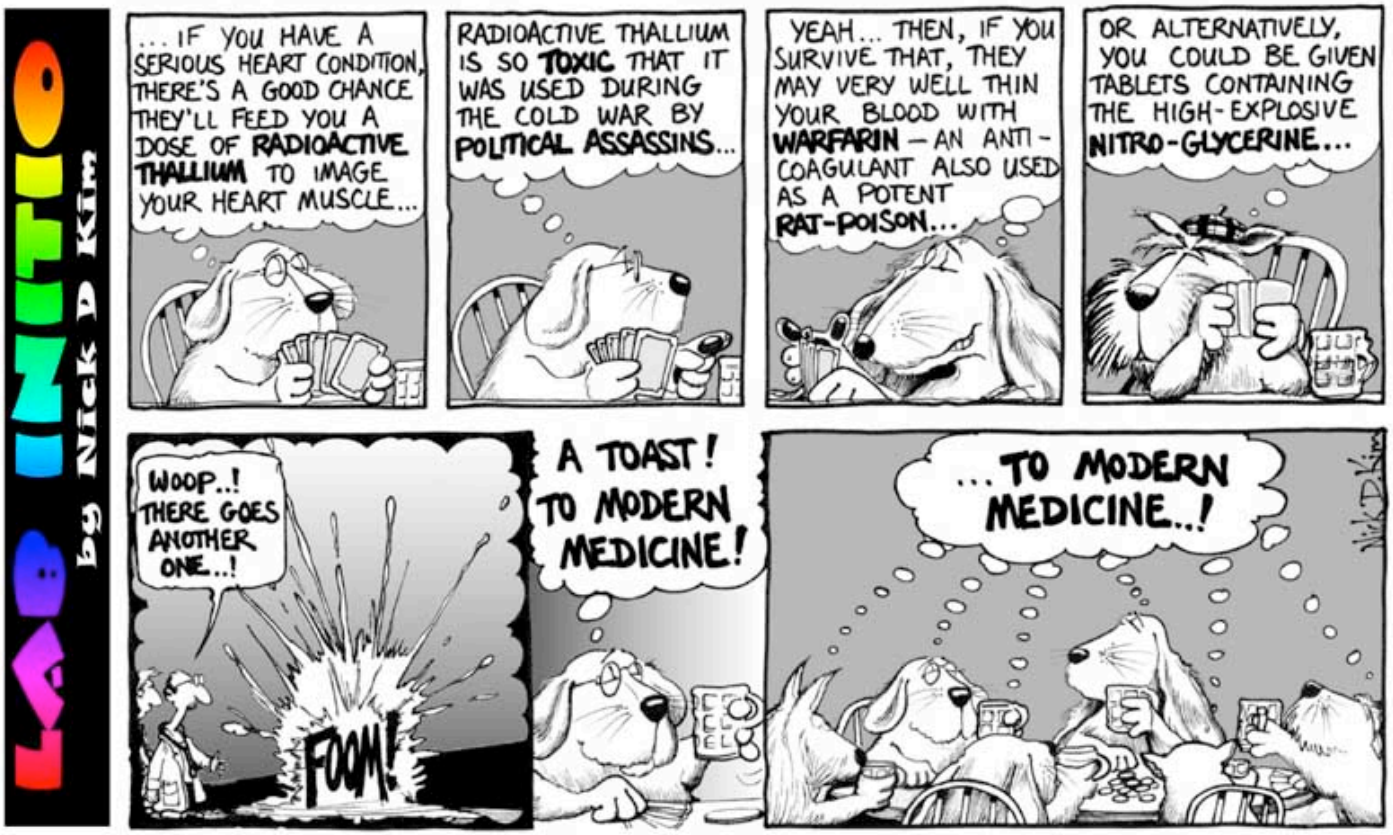
Chemistry 40S

Final Exam Review Package

Multiple Choice Section



Aqueous Reactions

1. What is the net ionic equation when solutions of silver nitrate and sodium acetate are mixed?
    a. $Na^+(aq) + NO_3^-(aq) \leftrightarrow NaNO_3(s)$
    b. $AgC_2H_3O_2(s) \leftrightarrow Ag^+(aq) + C_2H_3O_2^-(aq)$
    c. $Ag^+(aq) + C_2H_3O_2^-(aq) \leftrightarrow AgC_2H_3O_2(s)$
    d. There is no net ionic equation

2. A 0.1 mol/L solution of a certain metal ion will form a precipitate with 0.1 mol/L solutions of all of these ions; OH^-, CO_3^{2-}, SO_4^{2-}. Which metal ion fits this description?
    a. Ba^{2+}
    b. Fe^{2+}
    c. Mg^{2+}
    d. Pb^{2+}

3. Which of the following ions could be added to an aqueous mixture containing Pb^{2+} and Ba^{2+} to separate the ions by precipitating one of them?
    a. I^-
    b. NO_3^-
    c. PO_4^{3-}
    d. SO_4^{2-}

4. Which of the following compounds has a low solubility in water?
    a. NaCl
    b. AgBr
    c. $FeCl_2$
    d. $MgBr_2$

5. Identify the ionic species present in an aqueous solution of Ammonium phosphate.
    a. NH_4^+, P^{3-}, O_2
    b. N^{3-}, H^+, P^{3-}, O^{2-}
    c. NH_4^+, PO_4^{3-}
    d. N^{3-}, H^+, PO_4^{3-}

6. How many milliLitres of 1.55×10^{-3} mol/L $HNO_3(aq)$ are required to neutralize 100.0 mL of 1.90×10^{-4} mol/L $Mg(OH)_2(aq)$?
    a. 24.5 mL
    b. 12.3 mL
    c. 6.13 mL
    d. 49.0 mL

7. If 24.00 mL of 0.200 mol/L NaOH is added to 36.00 mL of 0.100 mol/L HCl, the pH of the resulting solution will be:
    a. 4.7
    b. 2.9
    c. 1.7
    d. 11.1

8. What are the products of a neutralization reaction between HCl and NaOH?

I. NaCl
II. H_2O
III. CO_2
IV. H_2

a. I and III only
b. I and II only
c. II and III only
d. II and IV only

9. Which of the following represents an oxidation reduction reaction?

a. $H_2CO_3 \rightarrow H_2O + CO_2$
b. $CuS + H_2 \rightarrow H_2S + Cu$
c. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
d. $2HCl + Na_2SO_3 \rightarrow 2NaCl + H_2O + SO_2$

10. What is the reducing agent in the following reaction?

$$Cu(s) + 4\ H^+(aq) + SO_4^{2-}(aq) \rightarrow Cu^{2+}(aq) + 2\ H_2O(l) + SO_2(g)$$

a. $SO_4^{2-}(aq)$
b. Cu (s)
c. $H^+(aq)$
d. $Cu^{2+}(aq)$

11. Balance the following equation in **acid** solution and indicate the coefficients of H_2S and H_2O.

$$MnO_4^- + H_2S \longrightarrow Mn^{2+} + S$$

The coefficients of H_2S and H_2O are, respectively,

a. 5, 8
b. 2, 6
c. 5, 10
d. 2, 4

12. How many electrons are transferred in the following reaction?

$$Cr + Cu^{2+} \longrightarrow Cr^{3+} + Cu$$

a. 6
b. 3
c. 4
d. 2

13. During an oxidation-reduction reaction, what happens to the reducing agent?

a. It accepts electrons.
b. It is oxidized.
c. It is reduced.
d. Its oxidation number decreases.

14. During the following reaction, $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$
    a. The oxidation state of carbon changes from +2 to +4.
    b. The oxidation state of carbon changes from -1 to +4.
    c. The oxidation state of carbon changes from 0 to +4.
    d. The oxidation state of carbon changes from 0 to -4.

15. Which of these half reactions is balanced?
    a. $Fe^{3+} \rightarrow Fe^{2+} + e$
    b. $MoO_3 + 2H^+ + 2e \rightarrow MoO_2^+ + H_2O$
    c. $MnO_2 + 4H^+ + 2e \rightarrow Mn^{2+} + 2H_2O$
    d. $VO_3^- + 3H^+ + e^- \rightarrow VO^{2+} + 2H_2O$

Atomic Structure:

16. What is the correct number of each particle in a fluoride ion, $^{19}F^-$?
    a. 9 protons, 10 neutrons, 8 electrons
    b. 9 protons, 10 neutrons, 9 electrons
    c. 9 protons, 10 neutrons, 10 electrons
    d. 9 protons, 19 neutrons, 10 electrons

17. Which of the following has the greatest frequency in the visible spectrum?
    a. Red light
    b. Orange light
    c. Green light
    d. Violet light

18. How many protons, neutrons and electrons are there in the species $^{26}Mg^{2+}$?
    a. 10 protons, 14 neutrons, 12 electrons
    b. 12 protons, 14 neutrons, 10 electrons
    c. 12 protons, 26 neutrons, 10 electrons
    d. 14 protons, 12 neutrons, 12 electrons

19. A certain sample of an element Z contains 60% of ^{69}Z and 40% of ^{71}Z. What is the relative atomic mass of element Z in this sample?
    a. 69.2 amu
    b. 69.8 amu
    c. 70.0 amu
    d. 70.2 amu

20. An element has 11 electrons orbiting the nucleus. In which group of the periodic table will it be found?
    a. Group 1
    b. Group 2
    c. Group 11
    d. Group 12

21. Emission of light from an atom occurs when an electron ____.
    a. drops from a higher to a lower energy level
    b. jumps from a lower to a higher energy level
    c. moves within its atomic orbital
    d. falls into the nucleus

22. How many 3d electrons are present in the ground state of a nickel atom?
    a. 6
    b. 7
    c. 8
    d. 9

23. What is the maximum number of orbitals in the *d* sublevel?
    a. 1
    b. 3
    c. 5
    d. 7

24. What family (group #) on the periodic table would have electrons with the configuration s^2p^5?
    a. 18
    b. 17
    c. 16
    d. 15

25. What is the noble gas configuration for calcium?
    a. [Ne]$3s^2$
    b. [Ne]$2s^2$
    c. [Ar] $3s^2$
    d. [Ar] $4s^2$

26. Which of the following increases across period 3 on the periodic table?
    I. Atomic radii
    II. Electronegativity
    III. Ionization energy
    a. I and II only
    b. I and III only
    c. II and III only
    d. I, II and III

27. Different forms of radiation arranged in order of decreasing wavelength are
    a. Radiowaves, gamma rays, visible light, UV light
    b. Radio waves, Visible light, UV rays, X rays
    c. Gamma rays, Radio waves, X rays, UV rays
    d. Radio waves, UV rays, Visible light, Gamma rays.

28. What neutral atom has the electron configuration $1s^22s^22p^63s^23p^64s^1$
    a. Na
    b. K
    c. Ca
    d. Cl

29. In the periodic table, reading from left to right and top to bottom, the elements are arranged in order of
    a. The number of protons in the nucleus
    b. The number of neutrons in the nucleus
    c. Increasing relative atomic mass
    d. Increasing mass number

30. Which of the following increases down a group?
    a. Electronegativity
    b. Atomic radii
    c. Ionization energy
    d. None of the above

Kinetics

31. For the reaction,

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$$

what is the average rate of consumption of oxygen gas in grams per minute if water is being produced at the rate of 2.2 g/min?
    a. 0.36 g/min.
    b. 1.83 g/min.
    c. 2.2 g/min.
    d. 11.0 g/min.

32. Consider the following reaction:

$$COCl_2(s) \rightarrow CO(g) + Cl_2(l)$$

Which of the following could be used to determine reaction rate in a closed container (not open to atmosphere)?
    a. a decrease in gas pressure
    b. an increase in gas pressure
    c. a decrease in the mass of the system
    d. an increase in the mass of the system

33. Consider the following reaction mechanism:

Step 1 $ClO^- + H_2O \rightarrow HClO + OH^-$
Step 2 $I^- + HClO \rightarrow HIO + Cl^-$
Step 3 $HIO + OH^- \rightarrow IO^- + H_2O$

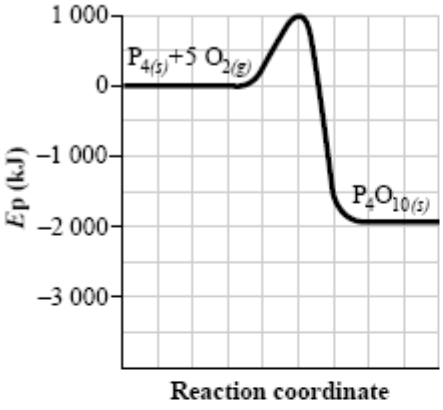
The catalyst is
    a. IO^-
    b. ClO^-
    c. H_2O
    d. $HClO$

34. The rate of a reaction in a system consisting of a solid and a gas depends on
    a. the amount of exposed surface of the solid only.
    b. the pressure of the gas only.
    c. the temperature only.
    d. all of the above.

35. Which of the following reactions would be the most rapid at room temperature?
    a. $Fe^{3+}(aq) + SCN^-(aq) \rightarrow FeSCN^{2+}(aq)$
    b. $2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$
    c. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
    d. $Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

36. When phosphorus, $P_4(s)$, is exposed to air, it ignites spontaneously and rapidly releases 2 940 kJ/mol. Which of the following potential energy diagrams best represents this reaction?

A.



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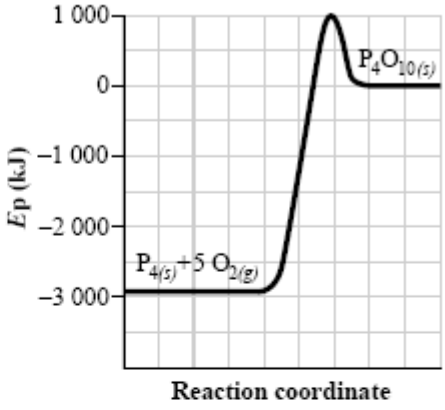

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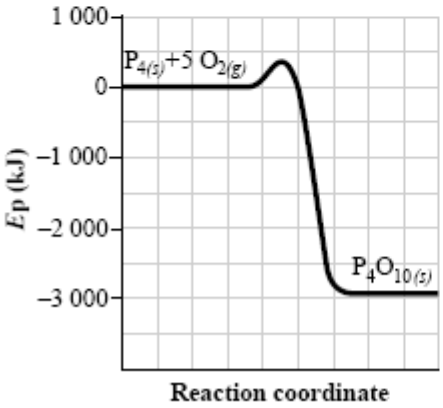
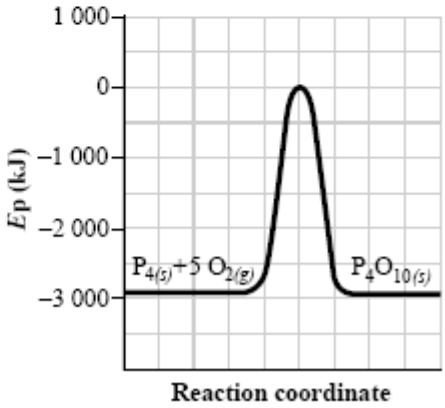


D.



37. Which one of the following could **NOT** be a unit for reaction rate?
    a. mol/L/s
    b. g/L/s
    c. g/min
    d. mol/L

38. As temperature increases, the rates of many chemical reactions increase because
    a. the kinetic energy of the molecules increase.
    b. the activation energy of the reaction is lowered.
    c. the heat content of reactants and products change.
    d. the heat of reaction is increased.

39. For the reaction $2\ NO + O_2 \leftrightarrow 2\ NO_2$ the following results were obtained:

trial	[NO] (mol/L)	[O_2] (mol/L)	Rate (mol/L/s)
1	0.12	0.05	0.12
2	0.12	0.10	0.24
3	0.24	0.05	0.48

What is the order of the reaction with respect to [NO]?

a. 0
b. 1
c. 2
d. 3

40. The decomposition of ozone, O_3, is believed to occur by the two-step mechanism below. What is the rate law of the reaction?

$O_3 \rightarrow O_2 + O$ (slow)
$O + O_3 \rightarrow 2O_2$ (fast)

$2O_3 \longrightarrow 3O_2$ (net reaction)

a. $R=k[O_3]^2$
b. $R=k[O_3]$
c. $R=k[O_2][O]$
d. $R=k[O_2]^3$

41. A catalyst increases the rate of a reaction by

a. increasing the temperature.
b. decreasing ΔH.
c. increasing the potential energy of the activated complex.
d. decreasing the activation energy.

42. Which of the following will decrease the number of effective collisions during a chemical reaction?

a. Adding a catalyst.
b. Increasing the surface area.
c. Decreasing the temperature.
d. Increasing reactant concentrations.

43. The reaction of an acid with a metal produces 1850 mL of $H_2(g)$ in 2 minutes and 25 seconds. The rate of this reaction could be expressed as

a. 12.8 mL/s.
b. 0.0074 mL/s.
c. 925 mL/min.
d. 3700 ml/min.

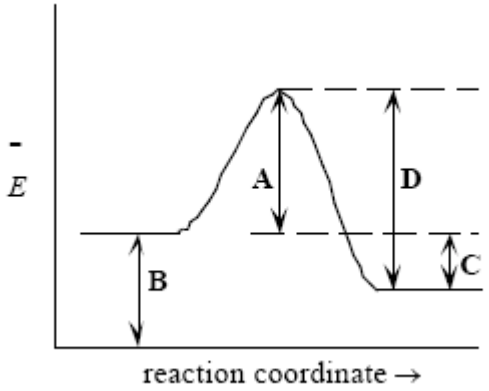
44. Consider the following factors:

I. concentration of reactants
II. temperature of reactants
III. surface area of reactants

The factors that affect the rate of a chemical reaction between two gases are

a. I and II only.
b. I and III only.
c. II and III only.
d. I, II and III.

45. Which line in the diagram represents the activation energy for a reverse reaction?



a. A
b. B
c. C
d. D

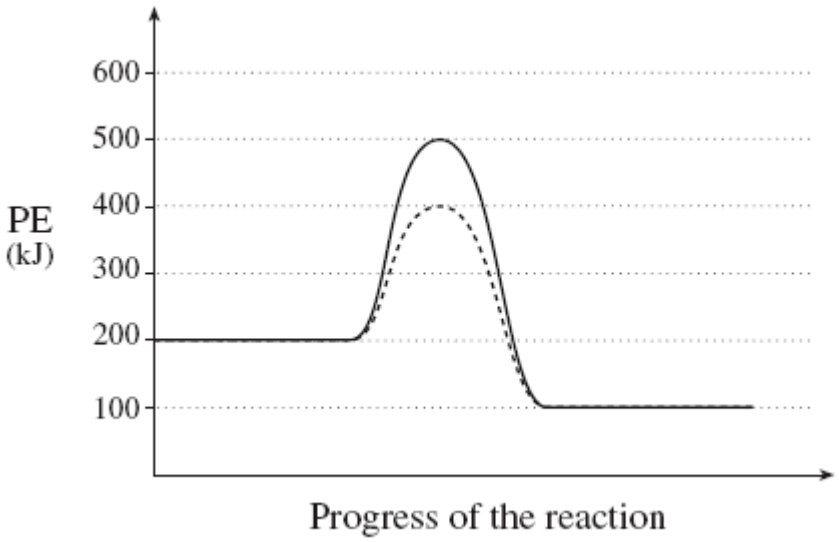
46. The reactions listed below are at the same conditions. Which one would be expected to be the fastest?

a. $C(s) + 2Cl_2(g) \rightarrow CCl_4(g)$
b. $Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$
c. $Pb^{2+}(aq) + Fe(s) \rightarrow Pb(s) + Fe^{2+}(aq)$
d. $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

47. When 100 mL of 1.0 mol/L HCl are added to 1 g of granular zinc at 25ºC, hydrogen is evolved. All of the following will increase the initial rate of hydrogen evolution **except**

a. substituting 2.0 mol/L HCl for 1.0 mol/L HCl.
b. using 200 mL of 1.0 mol/L HCl instead of 100 mL.
c. substituting powdered zinc for granular zinc.
d. increasing the temperature of the 1.0 mol/L HCl to 50ºC.

48. Consider the following potential energy diagram for a catalyzed and uncatalyzed reaction:



Which of the following describes the **REVERSE** reaction?

	Reverse Reaction	Activation Energy (kJ)	ΔH
a.	uncatalyzed	300	–100
b.	catalyzed	300	–100
c.	uncatalyzed	400	100
d.	catalyzed	400	100

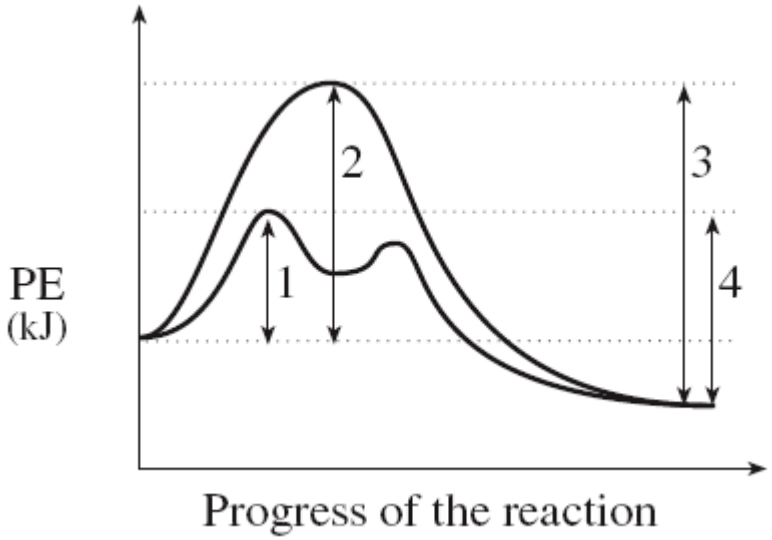
49. Consider the following reaction:

$$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$$

It was found that, at a certain time, that nitrogen, N_2, was being formed at a rate of 0.27 mol/L/s. At what rate was ammonia, NH_3, being used up?

a. 0.14 mol/L/s
b. 0.27 mol/L/s
c. 0.54 mol/L/s
d. 2.0 mol/L/s

50. Consider the following potential energy diagram:



Identify the activation energy for the forward uncatalysed reaction.

a. 1
b. 2
c. 3
d. 4

Chemical Equilibrium

51. Starting with equal moles of reactants, which of the following equilibrium systems most favours the reactants?

a. $SO_2(g) + NO_2(g) \leftrightarrow SO_3(g) + NO(g)$ $K_c = 3.4$
b. $CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g)$ $K_c = 31.4$
c. $H_2(g) + I_2(g) \leftrightarrow 2HI(g)$ $K_c = 10$
d. $N_2(g) + O_2(g) \leftrightarrow 2NO(g)$ $K_c = 1x10^{-31}$

52. Consider the following equilibrium:

$$N_2O_4\,(g) \leftrightarrow 2NO_2\,(g) \qquad K_c = 1.\,0 \times 10^{-2}$$

At equilibrium, the $[NO_2] = 2.0 \times 10^{-2}$ mol/L and the $[N_2O_4]$ is

a. 2.0 mol/L
b. 4.0×10^{-2} mol L
c. 4.0×10^{-6} mol L
d. 25 mol/L

53. A mixture contains 0.15 mol/L H_2, 0.042 mol/L S_2, and 0.33 mol/L H_2S. Which of the following statements is true if $K_c = 1.03 \times 10^{-6}$ at 700°C for the reaction

$$2H_2S(g) \leftrightarrow 2H_2(g) + S_2(g)?$$

a. The reaction will proceed from right to left.
b. The concentrations of the products will increase, while the concentration of the reactant will decrease.
c. The reaction is already at equilibrium.
d. The concentrations of H_2 and H_2S will decrease, since they are larger than the concentration of S_2.

54. A mixture of 0.100 mol of NO, 0.0500 mol of H_2, and 0.100 mol of H_2O is placed in a 1.00-L vessel. The following equilibrium is established:

$$2NO(g) + 2H_2(g) \leftrightarrow N_2(g) + 2H_2O(g)$$

At equilibrium [NO] = 0.0620 *M*.
Calculate the equilibrium concentrations of H_2, N_2, and H_2O.

a. $[H_2] = 0.0310$ mol/L; $[N_2] = 0.0190$ mol/L; $[H_2O] = 0.119$ mol/L
b. $[H_2] = 0.0120$ mol/L; $[N_2] = 0.0380$ mol/L; $[H_2O] = 0.138$ mol/L
c. $[H_2] = 0.0120$ mol/L; $[N_2] = 0.0190$ mol/L; $[H_2O] = 0.138$ mol/L
d. $[H_2] = 0.0500$ mol/L; $[N_2] = 0.0620$ mol/L; $[H_2O] = 0.100$ mol/L

55. Given $[COCl_2] = 0.299$ mol/L, $[Cl_2] = 6.01 \times 10^{-5}$ mol/L and $[CO] = 6.01 \times 10^{-5}$ mol/L for the following reaction at 150°C calculate the equilibrium constant.

$$COCl_2(g) \leftrightarrow CO(g) + Cl_2(g)$$

a. 8.32×10^{-9}
b. 2.32×10^{-8}
c. 6.45×10^{-9}
d. 1.21×10^{-8}

56. The equilibrium constant for the following reaction is 3.93 at 1200ºC. A system at equilibrium has [CO] = 0.0479 mol/L, $[CH_4] = 0.0521$ mol/L and $[H_2O] = 0.0521$ mol/L. What is the $[H_2]$?

$$H_2(g) + CO(g) \leftrightarrow CH_4(g) + H_2O(g)$$

a. 0.0144 mol/L
b. 0.212 mol/L
c. 0.243 mol/L
d. 0.271 mol/L

57. Consider the following reactions at equilibrium and determine which of the indicated changes will cause the reaction to proceed forward.

I. $CO(g) + 3\ H_2(g) \leftrightarrow CH_4(g) + H_2O(g)$ (add CH_4)
II. $N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g)$ (remove NH_3)
III. $H_2(g) + F_2(g) \leftrightarrow 2\ HF(g)$ (add F_2)
IV. $N_2(g) + 2\ O_2(g) \leftrightarrow 2\ NO_2(g)$ (remove O_2)
V. $BaO(s) + SO_3(g) \leftrightarrow BaSO_4(s)$ (add BaO)

a. II and III only
b. II, III and V only
c. I, IV and V only
d. I and IV only

58. The reversible reaction:

$$2\ SO_2(g) + O_2 \leftrightarrow 2\ SO_3(g)$$

has come to equilibrium in a vessel of specific volume and at a given temperature. Before the reaction, the concentrations of the reactants were 0.060 mol/L of SO_2 and 0.050 mol/L of O_2. No SO_3 was present. After equilibrium was reached, the concentration of SO_3 was 0.040 mol/L. What is the equilibrium constant, K_c, for this reaction?

a. 133
b. 4.0
c. 8.88
d. 13.3

59. Which of the following equations does NOT represent physical equilibria:

a. $H_2O(l) \leftrightarrow H_2O(g)$
b. $3O_2(g) \leftrightarrow 2O_3(g)$
c. $Na^+(aq) + Cl^-(aq) \leftrightarrow NaCl(s)$
d. $CO_2(s) \leftrightarrow CO_2(g)$

60. The numerical value of the equilibrium constant may be altered by changing the

a. volume of the reaction vessel.
b. partial pressure of any of the gases in the system.
c. the temperature of the system.
d. the concentrations of reactants and products.

61. If $H_2S(g)$ is removed from the container in the reaction below, the change that will result is

$$2Bi^{3+}(aq) + 3H_2S(g) \leftrightarrow Bi_2S_3(s) + 6H^+(aq) \qquad \Delta H = 25\ kJ$$

a. $[Bi^{3+}]$ will decrease
b. $[H^+]$ and $[Bi_2S_3]$ will increase
c. $[Bi^{3+}]$ and $[Bi_2S_3]$ will decrease
d. $[Bi^{3+}]$ will increase

62. In a reversible chemical reaction, which factors must be equal when the reaction is at equilibrium?

a. concentration of reactants and concentration of products
b. rate at which reactants are consumed and rate at which products are formed
c. potential energy of reactants and potential energy of products
d. activation energy of reactants and activation energy of products

63. Consider the following equilibrium:

$$3\ N_2O(g) + 2\ NH_3(g) \leftrightarrow 4\ N_2(g) + 3\ H_2O(l)$$

The equilibrium constant expression is

a. $K_c = \frac{[N_2O]^3[NH_3]^2}{[N_2]^4[H_2O]^3}$

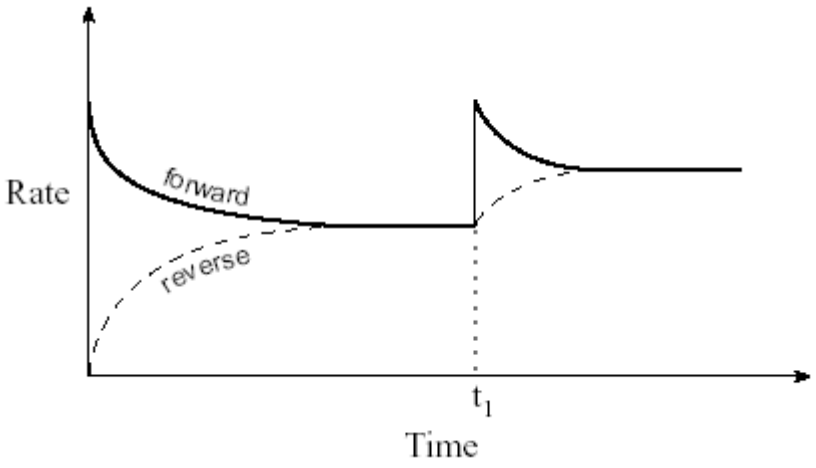
b. $K_c = \frac{[N_2]^4[H_2O]^3}{[N_2O]^3[NH_3]^2}$

c. $K_c = \frac{[N_2]^4}{[N_2O]^3[NH_3]^2}$

d. $K_c = \frac{[N_2O]^3[NH_3]^2}{[N_2]^4}$

64. Consider the rate diagram below for the following reaction:

$$2HI\ (g) \leftrightarrow H_2\ (g) + I_2(g)$$



Which of the following occurs at time t_1 ?

a. addition of H_2
b. addition of HI
c. addition of a catalyst
d. a decrease in volume

65. Consider the system

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

If the concentration of ammonia gas is tripled, the value of the equilibrium constant will

a. triple.
b. increase by more than a factor of three.
c. decrease to one-third its value.
d. remain the same.

66. Consider the following:

I. constant temperature

II. equal concentrations of reactants and products
III. equal rates of forward and reverse reactions

A system at equilibrium must have
a. I and II only.
b. I and III only.
c. II and III only.
d. I, II and III.

67. The following reaction strongly favours products at 25°C.

$$CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g)$$

Which one of the following K_c values would best be related to this reaction at the specified temperature?
a. 7.6×10^{-2}
b. 1.02×10^{5}
c. 4.56×10^{-8}
d. 56.2

68. What are two conditions necessary to establish a dynamic equilibrium?
a. constant temperature and open system
b. open system and reversible reaction
c. reversible reaction and closed system
d. variable temperature and reversible reaction

69. If a bottle 1/2 full of $H_2O(l)$ is tightly corked, equilibrium will be reached between $H_2O(g)$ and $H_2O(l)$ in the bottle. Which of the following is **incorrect**?
a. Raising temperature favors formation of more $H_2O(g)$.
b. Lowering temperature will decrease pressure on inside walls.
c. Water vapor pressure will increase as temperature increases.
d. Decreasing volume by pushing the cork farther in favors formation of more $H_2O(g)$.

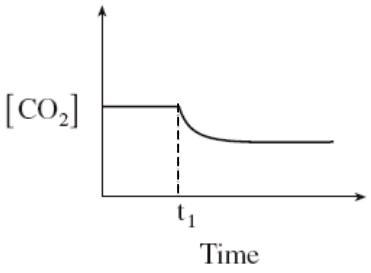
70. The solubility of AgI is 1.22×10^{-8} mol/L. What is the value of K_{sp} for AgI?
a. 1.1×10^{-4}
b. 1.2×10^{-8}
c. 5.7×10^{-2}
d. 1.5×10^{-16}

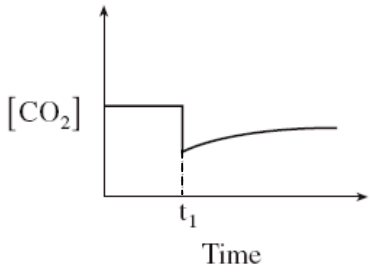
71. When a saturated solution of $Cr(OH)_3$ is formed, the concentration of Cr^{3+} is 1.26×10^{-8} mol/L. What is the value of K_{sp} for $Cr(OH)_3$?
a. 6.8×10^{-31}
b. 1.6×10^{-16}
c. 2.0×10^{-24}
d. 6.3×10^{-26}

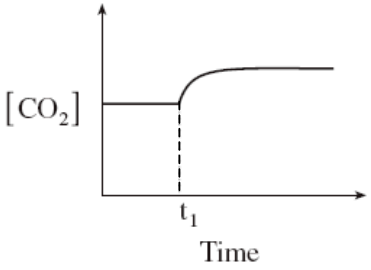
72. Consider the following equilibrium:

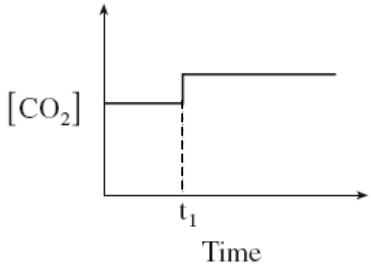
$$CaCO_3\,(s) \leftrightarrow CaO(s) + CO_2(g) \quad \Delta H = +175kJ$$

Which of the following diagrams best represents the change in the concentration of $CO_2(g)$ as temperature is decreased at time t_1 ?









73. The solubility of a solute is best determined from which type of solution?
    a. a saturated solution
    b. any solution at 25°C
    c. an unsaturated solution
    d. a supersaturated solution

74. Which expression correctly describes the K_{sp} for aluminum sulfide?
    a. $K_{sp} = [Al^{3+}][S_2^-]$
    b. $K_{sp} = [Al^{3+}]^2[S^{2-}]^3$
    c. $K_{sp} = \dfrac{[Al^{3+}][S^{2-}]}{Al_2S_3}$
    d. $K_{sp} = \dfrac{[Al^{3+}]^3[S^{2-}]^2}{Al_2S_3}$

75. Given the K_{sp} for FeS is 3.7×10^{-19}, the solubility of FeS in **g/L** is
    a. 6.1×10^{-10} g/L.
    b. 3.7×10^{-19} g/L.
    c. 5.3×10^{-8} g/L.
    d. 4.3×10^{-5} g/L.

76. Which of the following solids is *incorrectly* matched with its solubility product expression?
    a. $PbBr_2 : K_{sp} = [Pb^{2+}][Br^-]^2$
    b. $Ag_2S : K_{sp} = [Ag^+]^2[S^{2-}]$

c. $Ni(OH)_2 : K_{sp} = [Ni^{2+}][OH^-]^2$
d. $Ag_2CO_3 : K_{sp} = [Ag^+]^2[CO_3^{2-}]^3$

77. In a saturated solution, the rate of dissolving is
a. equal to zero.
b. equal to the rate of crystallization.
c. less than the rate of crystallization.
d. greater than the rate of crystallization.

78. What is the concentration of the fluoride ions in a saturated solution of BaF_2? (K_{sp} of $BaF_2 = 1.0 \times 10^{-6}$)
a. 6.3×10^{-3} mol/L
b. 1.0×10^{-3} mol/L
c. 2.0×10^{-2} mol/L
d. 1.3×10^{-2} mol/L

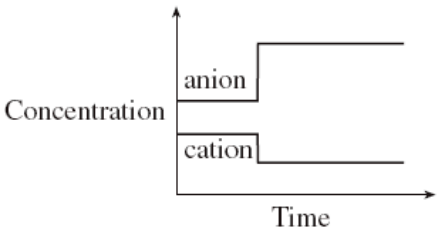
79. Consider the following solubility equilibrium:

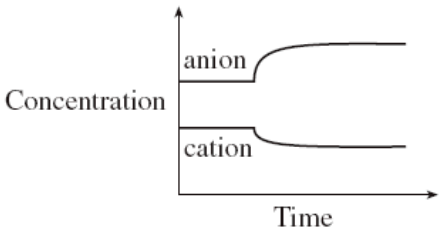
$$PbCl_2\,(s) \leftrightarrow Pb^{2+}(aq) + 2Cl^-(aq)$$

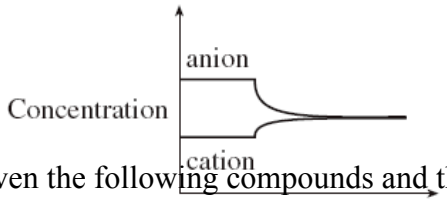
A student adds NaCl(s) to a saturated solution of $PbCl_2$. When equilibrium is reestablished, how have the concentrations changed from the original equilibrium?
a. $[Pb^{2+}]$ and $[Cl^-]$ both increased.
b. $[Pb^{2+}]$ and $[Cl^-]$ both decreased.
c. $[Pb^{2+}]$ decreased and $[Cl^-]$ increased.
d. $[Pb^{2+}]$ increased and $[Cl^-]$ decreased.

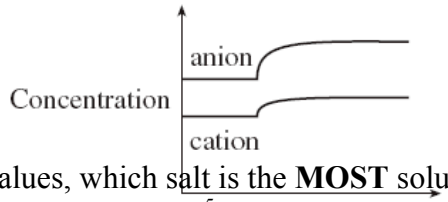
80. Which one of the following factors will change the value of the K_{sp}?
a. temperature
b. pressure
c. concentration
d. surface area

81. A saturated solution is prepared by dissolving a salt in water. Which of the following graphs could represent the ion concentrations as the temperature is changed?









82. Given the following compounds and their K_{sp} values, which salt is the **MOST** soluble?
a. calcium sulfate $K_{sp} = 2.4 \times 10^{-5}$
b. lead(II)sulfate $K_{sp} = 1.1 \times 10^{-8}$

c. silver chloride $K_{sp} = 1.8 \times 10^{-10}$
d. barium chromate $K_{sp} = 8.5 \times 10^{-11}$

83. The solubility of CuCl in water is 5.7×10^{-4} mol/L. The K_{sp} for CuCl is:
a. 5.7×10^{-8}
b. 3.2×10^{-7}
c. 3.2×10^{-4}
d. 3.1×10^{6}

Acid Base Equilibrium

84. A substance which produces hydrogen ions in solution is the definition of
a. an Arrhenius acid.
b. an Arrhenius base.
c. a Brönsted-Lowry acid.
d. a Brönsted-Lowry base.

85. Consider the following equilibrium constant expression:

$$K = \frac{[H_2S][OH^-]}{[HS^-]}$$

This expression represents the
a. K_b for HS^-
b. K_a for HS^-
c. K_a for H_2S
d. K_b for H_2S

86. What is the pH of 300 mL of 0.0040 mol/L HCl(aq)?
a. 2.40
b. 2.60
c. 2.92
d. 3.40

87. A solution has an H_3O^+ concentration of 2.3×10^{-4} mol/L? What is the OH^- ion concentration and is this solution acidic or basic?
a. 4.3×10^{-11} mol/L : acidic
b. 2.3×10^{-4} mol/L : acidic
c. 2.3×10^{-18} mol/L : acidic
d. 4.3×10^{-11} mol/L : basic

88. Calculate the percent ionization of the acid HF(aq) in 1.0 mol/L aqueous HF solution.
a. 7.2×10^{-4} %
b. 0.072 %
c. 2.58 %
d. 100 %

89. Consider the following equilibrium:

$$HC_6H_5O_7^{2-} + HIO_3 \leftrightarrow H_2C_6H_5O_7^- + IO_3^-$$

The order of Brönsted-Lowry acids and bases is

a. acid, base, acid, base
b. acid, base, base, acid
c. base, acid, acid, base
d. base, acid, base, acid

90. What is the K_a expression for the third ionization step of phosphoric acid?

a. $K_a = \frac{[H_3O^+][H_2PO_4^-]}{[H_3PO_4]}$

b. $K_a = \frac{[H_3O^+][PO_4^{3-}]}{[HPO_4^{2-}]}$

c. $K_a = \frac{[H_3O^+][HPO_4^{2-}]}{[H_2PO_4^-]}$

d. $K_a = \frac{[H_3O^+][H_2PO_4^-]}{[HPO_4^{2-}]}$

91. Which one of the following relationships are true?

a. The higher the [H^+] the higher the pH
b. The lower the pH, the lower the [OH^-]
c. The lower the [OH^-], the lower the [H^+]
d. The higher the [H_3O^+], the lower the [H^+]

92. The [OH^-] in a solution is 8.5×10^{-5} mol/L. What is the pH?

a. 8.50
b. 4.07
c. 7.00
d. 9.93

93. What is the K_a of a monoprotic weak acid, HX, if the hydronium ion concentration of a 0.400 mol/L solution is 1.40×10^{-4} mol/L?

a. 1.22×10^{-9}
b. 1.40×10^{-3}
c. 4.90×10^{-8}
d. 1.96×10^{-8}

94. What is the pH of a 0.470 mol/L solution of benzoic acid?

a. 2.25
b. 11.75
c. 1.01
d. 4.51

95. A 0.10 mol/L solution of a weak base is 8.1% ionized. What is the K_b?

a. 8.8×10^{-4}
b. 7.6×10^{-4}

c. 6.6×10^{-4}
d. 8.4×10^{-4}

96. An example of a nonelectrolyte is
    a. $C_6H_{12}O_6(aq)$.
    b. $NaCl(aq)$.
    c. $K_2SO_4(aq)$.
    d. $HCl(aq)$.

97. Citric acid, which is extracted from citrus fruits and pineapple waste, is used extensively in the manufacture of candy and soft drinks. Which of the following is a characteristic of a citric acid solution?
    a. a bitter taste
    b. a sour taste
    c. the ability to neutralize vinegar
    d. the ability to turn litmus from red to blue

98. What happens to the concentration of the hydroxide ion if the pH decreases from 11.5 to 8.5 during a reaction?
    a. It decreases by a factor of 3.
    b. It decreases by a factor of 1000.
    c. It increases by a factor of 3.
    d. It increases by a factor of 1000.

Electrochemistry

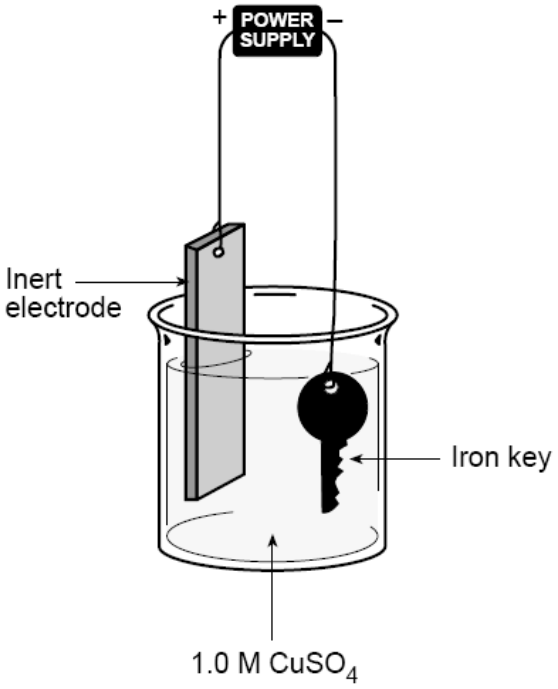
99. What is $E°$ for the reaction

$$2Al(s) + 3Zn^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Zn(s) \text{ ?}$$

    a. +5.62 V
    b. +2.43 V
    c. +0.90 V
    d. −0.90 V

100. In an electrochemical cell consisting of zinc and silver in appropriate solutions, which of the following is **TRUE**?
    a. the zinc electrode gains mass and the silver electrode loses mass
    b. electrons flow from the silver electrode to the zinc electrode
    c. cations in the solution move toward the silver electrode
    d. the voltage remains constant as the cell operates

101. Consider the following diagram:



The half-reaction at the cathode is

a. $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
b. $2SO_4^{2-}(aq) \rightarrow S_2O_8^{2-}(aq) + 2e^-$
c. $H_2O \rightarrow 1/2O_2(g) + 2H^+(aq) + 2e^-$
d. $2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

102. Which reaction occurs at the **cathode** in the following electrochemical cell:

$Mg / Mg^{2+} // Sn^{2+} / Sn$

a. Mg becomes oxidized
b. Mg^{2+} becomes reduced
c. Sn^{2+} becomes reduced
d. Sn becomes oxidized

103. Based on the following information, arrange the four metal ions A^+, B^+, C^+, and D^+ in order of decreasing strength of oxidizing agents.

Only metals A , B and C react with H^+ to give H_2.
When C is added to solutions of the other metal ions, metallic B and D are formed.
Metal C does not reduce A^+.

a. $A^+ > C^+ > B^+ > D^+$
b. $C^+ > A^+ > D^+ > B^+$
c. $D^+ > B^+ > C^+ > A^+$
d. $A^+ > C^+ > D^+ > B^+$

104. Which one of the following is **NOT** characteristic of electroplating?

a. The reduction half-reaction occurs at the cathode of an electroplating electrolytic cell.
b. The object to be plated is set up as the anode in an electrolytic cell.
c. The electrolytic solution contains ions of the metal to be plated.
d. The anode must be made of the plating material.

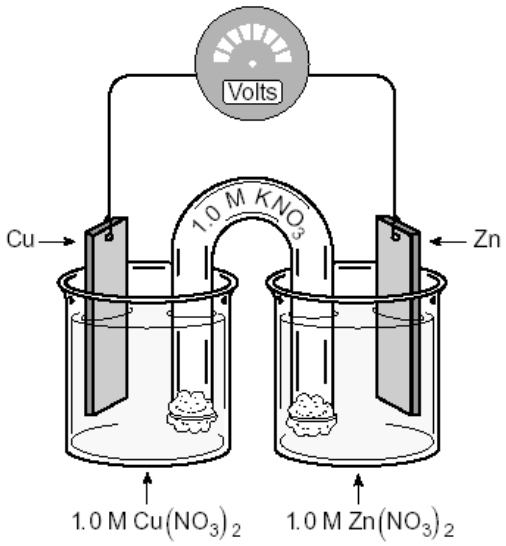
105. Predict which of the following metal(s) would react with a solution of copper(II) ions.

a. zinc only

b. iron, zinc, and aluminum
c. aluminum only
d. silver only

106. The electrolysis of molten sodium bromide yields Br_2 by
a. oxidation at the anode, the positive electrode.
b. oxidation at the cathode, the positive electrode.
c. reduction at the anode, the negative electrode.
d. reduction at the cathode, the negative electrode.

Use the following electrochemical cell diagram to answer question 96.



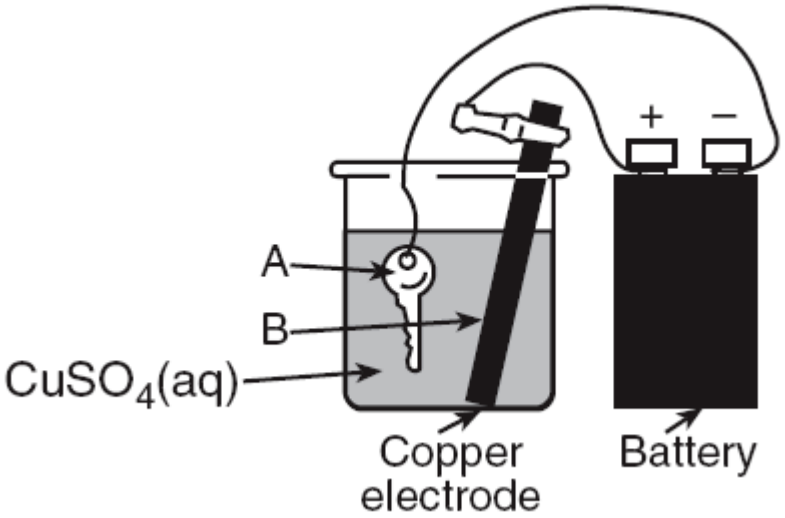
As the above cell operates,
a. copper ions migrate into the salt bridge
b. cations migrate towards the zinc electrode.
c. the mass of the copper electrode increases.
d. anions migrate towards the copper electrode.

107. In an experiment, strips of metals A, B, and C were placed in beakers containing solutions of A^{4+}, B^{3+}, and C^{2+} and were allowed to react. The following data was obtained.

	A(s)	B(s)	C(s)
A^{4+} (aq)	X	reaction	reaction
B^{3+} (aq)	no reaction	X	no reaction
C^{2+} (aq)	no reaction	reaction	X

Arranging these metal ions in order of decreasing tendency to attract electrons gives which of the following?
a. $A^{4+} > B^{3+} > C^{2+}$
b. $A^{4+} > C^{2+} > B^{3+}$
c. $B^{3+} > C^{2+} > A^{4+}$
d. $B^{3+} > A^{4+} > C^{2+}$

108. The diagram below shows a key being plated with copper.



Given the reduction reaction for this cell:

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

This reduction occurs at

a. *A,* which is the anode.
b. *A,* which is the cathode.
c. *B,* which is the anode.
d. *B,* which is the cathode.

109. A beaker contains a small amount of gold dust (Au(s)). Which of the following aqueous solutions, when added to the beaker, would dissolve the gold dust (ie convert Au(s) to $Au^{3+}(aq)$)?

a. $Cr_2O_7^{2-}$(acidic solution)
b. H_2O_2(acidic solution)
c. Br_2
d. Zn^{2+}

110. Which of the following statements about the standard hydrogen electrode is true?

a. Hydrogen gas is bubbled through the electrode at a pressure of 2 atm.
b. The electrode contains a copper wire that serves as a chemically inert surface for reduction – oxidation reactions to occur.
c. The electrode contains a platinum wire that serves as a chemically inert surface for reduction – oxidation reactions to occur.
d. The standard hydrogen electrode is assigned a half cell potential of 1.0 V.