

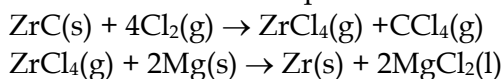
## Contents

<u>Topic</u>	<u>Question Numbers</u>
Atoms and Molecules .....	1 to 14
Gases .....	15 to 22
Chemical Kinetics .....	23 to 29
Chemical Equilibrium .....	30 to 36
Thermodynamics .....	37 to 49
Properties of Solutions .....	50 to 59
Heat Capacity, Phase Changes and Colligative Properties .....	60 to 73
Acids and Bases .....	74 to 87
Electrochemistry .....	88 to 100

### Atoms and Molecules

1. Answer: D

Based on the balanced equations:



$5\text{ mol Cl}_2(\text{g})/4 < 2\text{ mol ZrC(s)}/1$ ,  $5\text{ mol Cl}_2(\text{g})$  is the limiting reactant

$$\begin{aligned} 5\text{ mol Cl}_2(\text{g}) \times 1\text{ mol Zr(s)}/4\text{ mol Cl}_2(\text{g}) \\ = 1.25\text{ mol} \end{aligned}$$

2. Answer: A

$$2.00 \times 10^{-3}\text{ mol H}_2\text{SO}_4 \times \frac{4\text{ mol O}}{1\text{ mol H}_2\text{SO}_4} \times \frac{6.022 \times 10^{23}\text{ atoms}}{1\text{ mol}} = 4.82 \times 10^{21}$$

3. Answer: A

$5\text{ moles Sb}/2 > 5\text{ mol Cl}_2/3$ ,  $5\text{ mol Cl}_2$  are the limiting reactant.

$5\text{ mol Cl}_2 \times 2\text{ mol Sb}/3\text{ mol Cl}_2 = 3.3\text{ mol Sb}$  used, therefore  $1.7\text{ mol Sb}$  remain.

4. Answer: B

Mass of the solvent in 1 L solution =

$$\begin{aligned} 1\text{L} \times \frac{1000\text{mL}}{1\text{L}} \times \frac{1.30\text{g}}{1\text{mL}} - 8\text{mol KOH} \times \frac{56\text{g}}{1\text{mol}} \\ = 852\text{g} \end{aligned}$$

$$\text{The molality of the solution} = \frac{8\text{mol}}{0.852\text{kg}}$$

$$= 9.39\text{m}$$

5. Answer: D

Titanium is a group 4 metal with 4 valence electrons. The 4s energy level is lower in energy than the 3d energy level, therefore the 4s will fill first with 2 valence electrons and the remaining 2 electrons will go in the 3d energy level.

6. Answer: D

$$\begin{aligned} E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\text{ Js})(3.0 \times 10^8\text{ m/s})}{(285 \times 10^{-9}\text{ m})} \\ = 6.98 \times 10^{-19}\text{ J} \end{aligned}$$

multiply by  $N_{\text{AV}}$  to get  $4.2 \times 10^5\text{ J}$

7. Answer: C

$l = 0, 1, \dots (n-1)$ , therefore if  $n = 3$ , then  $l$  cannot equal 3.

8. Answer: A

$\text{Se}^{2-}$  will have the largest radius because it has the largest atomic number and has d-orbitals.

9. Answer: B

(i) is false because Cs and Fr are the two least electronegative elements. (ii) is false because Ti has two unpaired electrons in its ground state. (iii) is true. K is "happier" ionized therefore its ionization energy will be very small. Ne on the other hand is a noble gas, which does not like to be ionized.

10. Answer: C

Only (i) is correct. This is because  $O^{2-}$  ion has more electron than O atom therefore it will have a larger radius. (ii) is false because the first ionization energy of Br will be smaller than Se. (iii) is false because O is more electronegative than C.

11. Answer: C

The first ionization energy is the energy required to remove the first electron in an atom from the ground state. As you move across a period the first ionization energy increases. As you move down a group the first ionization energy decreases, therefore K will have the lowest first ionization energy.

12. Answer: B

The most ionic bond will have the most electronegative species and the least electronegative species. Electronegativity increases as you move across and up the periodic table. F is the most electronegative and Li, here, is the least E.N.

13. Answer: D

i) is incorrect - electrons try to minimize the energy of the atom  
 ii) is correct - Pauli's Exclusion Principle  
 iii) is incorrect - orbitals with the same energies are called degenerate

14. Answer: D

The group number assigned to each group/column (when referring to groups 1, 2, and 13-18) indicates the number of valence electrons each atom has in that particular group. Since all elements in the same group have the same number of valence electrons, they share similarities in their chemical properties.

## Gases

15. Answer: B

Molar Mass =

$$\frac{dRT}{P} = \frac{1.25 \text{ g L}^{-1} (0.08206 \text{ atm L / mol K})(273 \text{ K})}{1.0 \text{ atm}}$$

$$= 28 \text{ g/mol}$$

16. Answer: A

$PV = nR(t+273.15)$  and  $P = (nR/V)t + 273.15nR/V$ . This is a linear plot with a positive slope and a positive y intercept.

17. Answer: D

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$T_2 = \frac{P_2}{P_1} \times \frac{V_2}{V_1} \times T_1 = \frac{0.34}{1} \times \frac{5.00 \times 10^3}{2.00 \times 10^3} \times 300.15 \text{ K}$$

$$T_2 = 255 \text{ K} \rightarrow -18^\circ\text{C}$$

18. Answer: A

$u_{ave} = (8 RT / \pi M)^{1/2}$ , where M is molecular mass. Therefore because  $O_2$  has a larger molecular mass than  $H_2$ , the  $H_2$  molecules will move faster

19. Answer: A

$$P(O_2) = 756 \text{ Torr} - 23.8 \text{ Torr} = 732.2 \text{ Torr}$$

$$n(O_2) = \frac{PV}{RT} = \frac{(732.2 / 760 \text{ atm})(0.332 \text{ L})}{(0.0821 \text{ atm L K}^{-1} \text{ mol}^{-1})(298.15 \text{ K})} = 0.01307 \text{ mol}$$

$$n(O_2)_{\text{(expected)}} = 1.23 \text{ g KClO}_3 \frac{1 \text{ mol KClO}_3}{122.55 \text{ g KClO}_3} \times \frac{3}{2} = 0.01506$$

$$\text{Yield} = \frac{0.01307}{0.01506} \times 100\% = 86.8\%$$

20. Answer: B

$$\frac{\text{rate}(X)}{\text{rate}(\text{CO}_2)} = 1.7 = \sqrt{\frac{M(\text{CO}_2)}{M(X)}}$$

$$M(\text{CO}_2) = 44.01 \text{ g/mol} = (1.7)^2 M(X)$$

$$M(X) = 15.1 \text{ g/mol} \dots \text{i.e. CH}_4 \text{ from the list}$$

21. Answer: D

Equal volumes of any ideal gas at STP contain equal numbers of moles or molecules.

22. Answer: C

The expansion of the gas does work, so the internal energy of the gas decreases. If the internal energy of the gas decreases, the average kinetic energy also decreases. Temperature is a measure of average kinetic energy.

### Chemical Kinetics

23. Answer: C

[NO] <sub>0</sub>	[O <sub>2</sub> ] <sub>0</sub>	Initial Rate
1×10 <sup>18</sup>	1×10 <sup>18</sup>	2.0×10 <sup>16</sup>
2×10 <sup>18</sup>	1×10 <sup>18</sup>	8.0×10 <sup>16</sup>

As the concentration of NO doubles, rate is four times larger, therefore [NO]<sup>2</sup>

[NO] <sub>0</sub>	[O <sub>2</sub> ] <sub>0</sub>	Initial Rate
1×10 <sup>18</sup>	1×10 <sup>18</sup>	2.0×10 <sup>16</sup>
1×10 <sup>18</sup>	2×10 <sup>18</sup>	4.0×10 <sup>16</sup>

As the concentration of O<sub>2</sub> doubles, rate doubles, therefore [O<sub>2</sub>]

$$\text{Therefore Rate} = k[\text{NO}]^2[\text{O}_2]$$

24. Answer: C

k does not depend on the order of the reaction, it is temperature dependent and also depends on the nature of the reactants.

25. Answer: B

It cannot be iii as the first step is the rate determining step.

For ii: slow step rate = k[E][A] and fast equilibrium rate = k<sub>1</sub>[A][B] = k<sub>-1</sub>[E][B]  
[E] = k[A][B], therefore rate = [A]<sup>2</sup>[B]

26. Answer: D

Second order therefore,  
Rate = k[AB]<sup>2</sup> = 1/time

$$\frac{1}{[\text{AB}]} = \frac{1}{[\text{AB}]_0} + kt, \text{ from } y = b + mx \text{ we can}$$

see that a plot of 1/[AB] vs. time would give a straight line.

27. Answer: C

A catalyst only affects a reaction by lowering the activation energy of the forward and reverse reaction.

28. Answer: B

The reaction rate is directly proportional to the concentration of the reactant in a first order reaction. Therefore, if the concentration of *tert*-butyl bromide is doubled, the reaction rate will double. Changing the concentration does not change the rate constant.

29. Answer: B

Catalysts do not change the position of equilibrium, so they don't change the equilibrium constant. Catalysts increase the rates of both the forward and reverse reactions.

Chemical Equilibrium

30. Answer: D

The second equation is in the reverse direction and it is halved. Therefore in the reverse direction the equilibrium constant is  $1/K$ , but because the second reaction is also halved the equilibrium constant is  $1/K^{1/2}$ .

31. Answer: D

$Q = [\text{NO}]^2[\text{Cl}_2]/[\text{NOCl}]^2 = (1.2)^2(0.6)/(1.3)^2 = 0.51 = K$ , therefore we are already at equilibrium.

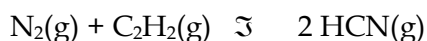
32. Answer: C

An increase in volume will shift the equilibrium to the right thus causing an increase in the total moles of CO at equilibrium.

33. Answer: A

Remember: Solids and liquids are not included in the expression.

34. Answer: A



$\Rightarrow Q=1 > K$  so then rxn goes to the left

i: 1.00 1.00 1.00

c: +x +x -2x

e: 1.00+x 1.00+x 1.00-2x

$$\frac{(1.00 - 2x)^2}{(1.00 + x)^2} = K_c \Rightarrow \frac{(1.00 - 2x)}{(1.00 + x)} = \sqrt{K_c}$$

$$x = \frac{1 - \sqrt{K_c}}{2 + \sqrt{K_c}} = 0.488$$

$$[\text{HCN}] = 1.00 - 2(0.488) = 0.024 \text{ mol L}^{-1}$$

35. Answer: B

The change in enthalpy for a reaction remains the same whether the reaction is at equilibrium or not.

36. Answer: D

Reactions always move toward equilibrium, so A and B are both wrong. If  $Q$  is less than  $K$ , the ratio of products to reactants is less than it is at equilibrium, so the reaction shifts to the right to reach equilibrium.

Thermodynamics

37. Answer: A

$$\begin{aligned} q &= q(\text{water}) + q(\text{calorimeter}) \\ &= (4.18)(1200)(3.54) + (837)(3.54) \\ &= 20.72 \text{ kJ} \end{aligned}$$

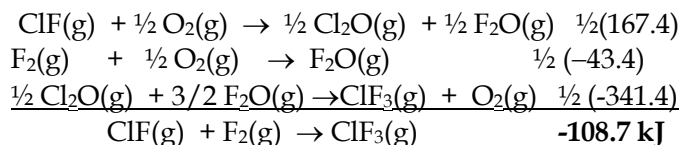
the moles of  $\text{N}_2\text{H}_4 = 1\text{g}/32 = 0.031$  moles

therefore the heat of combustion is

$$= -20.72 \text{ kJ}/0.031 \text{ moles}$$

$$= -665 \text{ kJ/mol}$$

38. Answer: D



39. Answer: C

The metal with the highest rise in temperature will be the metal with the lowest specific heat capacity. Specific heat capacity measures the amount of heat 1g of a substance can absorb before it rises in temperature by  $1^\circ\text{C}$ . Sr has the lowest specific heat capacity and therefore will rise in temperature the most.

40. Answer: D

Hint: since ice remains after the mixture, the final temperature must be 0 degrees since we are mixing the two together, the two heats must be equal to each other (ie. The heat lost of one must equal the heat gained for the other) therefore,  $q = q$  so, for the water we have  $q = mCT = (150)(4.184)(75-0) = 47.07 \text{ kJ}$  therefore the heat that goes into melting the ice is 47.07 kJ

Now for the ice we have,  
 $47.07 \text{ kJ} = n(\text{heat of melting}) = n(6.02 \text{ kJ})$   
 therefore,  $n = 47.07/6.02 = 7.82$  moles of ice melted

To find the mass we use  
 $m = MM \times n = 18 \text{ g/mol} \times 7.82 = 140.8 \text{ g}$  of ice melted  
 therefore the amount of ice left over is  $= 180 - 140.8 = 39.2 \text{ g}$

41. Answer: B

To find the  $\Delta H_f^\circ$  for  $\text{As}_2$ , use the following equation. Remember that the  $\Delta H_f^\circ = 0$  for pure elements in their natural state.

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \Delta H_f^\circ \text{ reactants}$$

$$\Delta H_f^\circ \text{ reactants} = \Delta H_f^\circ \text{ products} - \Delta H^\circ$$

$$2(-786 \text{ kJ}) - (-1794) = +222 \text{ kJ}$$

Since there is only one mole of  $\text{As}_2$ ,  $\Delta H_f^\circ$  for  $\text{As}_2 = +222 \text{ kJ/mol}$

42. Answer: D

$\Delta H$  only equals  $q$  if the reaction is carried out at constant pressure.  $\Delta H$  does not always equal  $\Delta U$ .  $\Delta H$  for an endothermic reaction is positive.

43. Answer: B

$$\text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g)$$

$$q = \Delta H = 40.0 \text{ kJ} \text{ (pressure is constant)}$$

$$w = -P_{\text{ext}} \Delta V = -P_{\text{ext}} (V_{\text{gas}} - V_{\text{liq}})$$

$$\approx -P_{\text{ext}} V_{\text{gas}} = n_{\text{gas}} RT$$

$$n_{\text{gas}} RT = -(1 \text{ mol}) (8.3145 \text{ JK}^{-1} \text{ mol}^{-1}) (373 \text{ K})$$

$$= -3101 \text{ J} = 3.10 \text{ kJ}$$

$$w/q = 3.10 \text{ kJ} / 40.0 \text{ kJ} = 0.078$$

44. Answer: A

moles of water  
 $= 250 \text{ mL} \times 1.0 \text{ g/mL} \times 1 \text{ mol}/18 \text{ g} = 13.9 \text{ mol water}$   
 Amount of heat required  
 $= \text{mol water} \times \Delta T \times \text{heat capacity}$   
 $= (13.9 \text{ mol})(75 \text{ K})(75.3 \text{ J K}^{-1} \text{ mol}^{-1}) = 78.4 \text{ kJ}$   
 $78.4 \text{ kJ} \times 1 \text{ sec}/0.100 \text{ kJ} = 784 \text{ seconds}$

45. Answer: C

$\Delta H = \text{exothermic} = \text{neg. value}$  and  
 $\Delta n(g) = 1 - 1 - 1 = -1$ . Hence,  $\Delta S = -\text{value}$ . At certain low  $T$  ( $-T\Delta S$ ) term remains negative value,  $\Delta H = \text{neg. value}$ , and give the overall  $\Delta G = \text{neg. value}$ .

46. Answer: A

A.  $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l) \Rightarrow$  melting process requires energy. Hence,  $\Delta H = \text{pos. value}$   
 B.  $\text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(l) \Rightarrow$  condensation process releases energy. Hence,  $\Delta H = -\text{value}$   
 C. and D. : combustion reactions are exothermic. Hence,  $\Delta H = -\text{values}$ .

47. Answer: A

Work and heat are not state functions.

48. Answer: D

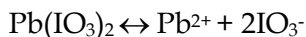
Since work is not a state function, its value will depend on the path taken.

49. Answer: B

When a gas is compressed the surroundings do work on the gas.

### Properties of Solutions

50. Answer: D

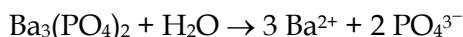


$$K_{\text{sp}} = [\text{Pb}^{2+}][\text{IO}_3^-]^2 = 4x^3, \text{ where}$$

$$2x = 7.4 \times 10^{-5} \text{ M}, \text{ therefore } x = 3.7 \times 10^{-5} \text{ M}$$

$$K_{\text{sp}} = 4(3.7 \times 10^{-5})^3 = 2.0 \times 10^{-13}$$

51. Answer: C



$$K_{\text{sp}} = [\text{Ba}^{2+}]^3[\text{PO}_4^{3-}]^2$$

52. Answer: D

$$0.96 \text{ mol/L} \times 0.125 \text{ L} = 0.12 \text{ mol iron (III) bromide}$$

$$0.12 \text{ mol FeBr}_3 \times \frac{3 \text{ mol Br}}{1 \text{ mol FeBr}_3} \times 1 / (0.04 + 0.125) \text{ L} = 2.2 \text{ M}$$

53. Answer: D

Water is also a polar solvent. "Like dissolve like", therefore Q will be miscible in water.

54. Answer: D

$$P_{\text{Benzene}} + P_{\text{Toluene}} = P_{\text{Total}} = ?$$

Solve for  $P_{\text{Total}}$ :

$$\begin{aligned} P_{\text{T}} &= \frac{1}{3}(119.3) + \frac{2}{3}(36.66) \\ &= 39.77 + 24.44 \\ &= 64.21 \text{ mmHg} \end{aligned}$$

55. Answer: D

(ii) and (iii) are true. (i) is false because in order to separate a solution of two liquids by distillation, the boiling points of the pure liquids must be different in value.

56. Answer: B

Flask B is the non-polar solvent therefore it will boil before the salt and water solutions.

57. Answer: D

As temperature changes molarity will change ( $M = n/V$ , where Volume is temperature dependent).

58. Answer: D

**Raoult's Law:** *solvent* vapor pressure is not zero and changes with the composition of the solution at a fixed temperature  $P_1 = X_1P_1^\circ$ . (i) is true, (ii) is false, (iii) is true.

59. Answer: A

$$167 \times 10^{-3} \text{ mol/L} \times 0.1 \text{ L} \times 58.44 \text{ g/mol} = 0.976 \text{ g}$$

### Heat Capacity, Phase Changes, and Colligative Properties

60. Answer: C

On the diagram, the left portion is the gas, the central portion is liquid and the right lower portion is a gas.

61. Answer: C

Statement C is incorrect because a liquid can boil at many temperatures as boiling point depends on pressure.

62. Answer: D

The vapour pressure will decrease as the non-volatile solute is added, the boiling point will increase, the freezing point will decrease, and the osmotic pressure will increase.

63. Answer: A

$$\begin{aligned} &(150 \text{ g metal})(\text{specific heat})(80-23.3) \\ &= (150 \text{ g water})(4.18 \text{ J} \cdot \text{g}^{-1} \cdot ^\circ\text{C}^{-1})(23.3-20) \\ &\text{specific heat of metal} = 0.24 \text{ J} \cdot \text{g}^{-1} \cdot ^\circ\text{C}^{-1} \end{aligned}$$

64. Answer: A

At equilibrium the rate of evaporation is equal to the rate of condensation.

65. Answer: C

Increasing the temperature increases the kinetic energy of the molecules in the liquid causing the molecules to move more quickly and increase the vapor pressure.

66. Answer: D

NH<sub>3</sub> will liquefy first because it has a dipole moment and therefore more intermolecular interactions.

67. Answer: D

An increase in the attractive intermolecular forces necessitates a greater amount of energy for a liquid molecule to escape to the vapour phase. Therefore, vapour pressure decreases as intermolecular forces increase.

68. Answer: C

Even though the pressure is slightly lower than the vapour pressure of the liquid, the compound will still be in equilibrium between the liquid and the gas state.

69. Answer: D

We can eliminate 'A' and 'B' as antifreeze should bring T<sub>f</sub> below the normal freezing point of water.

$$T_f = 0^\circ\text{C} - 1.86 \frac{^\circ\text{C} \cdot \text{kg}}{\text{mol}} \times \frac{1}{0.9\text{kgWater}} \times \frac{1\text{molEthyleneGlycol}}{62\text{g}} \times 200\text{gEG}$$

$$T_f = -6.7^\circ\text{C}$$

70. Answer: C

The change in freezing point for a solute in a solvent in varying concentrations depends on the molality, the freezing point depression constant K<sub>f</sub>, and the freezing point of the pure solvent, T<sub>f</sub><sup>o</sup>.  $\Delta T_f = T_f^o - T_f = K_f(\text{molality})$ .

71. Answer: B

There will be more moles of ions present in the 0.1M solution for Na<sub>2</sub>SO<sub>4</sub>, therefore it will have a lower freezing point.

72. Answer: A

$$\Pi = [\text{Lysozyme}]RT =$$

$$8.90\text{torr} \times \frac{1\text{atm}}{760\text{torr}} = [\text{Lysozyme}](0.0821\text{Latm/molK})(298\text{K})$$

$$[\text{Lysozyme}] = 0.000479\text{M},$$

moles lysozyme

$$= 0.000479\text{M} \times \left( 0.15\text{kg} \times \frac{1\text{L}}{1\text{kg}} \right) = 7.19 \times 10^{-5} \text{ moles}$$

$$\text{molar mass} = \frac{0.100\text{g}}{7.19 \times 10^{-5} \text{ mol}} = 1.39 \times 10^3 \text{ g/mol}$$

73. Answer: A

The cucumber is mostly water inside. Because the outside solution has a higher concentration of salt than the cucumber water is going to flow from the cucumber to the outside solution in an attempt to equilibrate the salt concentration.

**Acids and Bases**

74. Answer: D  
The strongest conjugate base will result from the weakest acid, which has the smallest  $K_a$  or largest  $pK_a$ .
75. Answer: C  
 $pH = -\log [H^+]$ , but  $pOH = -\log [OH^-]$  and  
 $pOH = 14 - pH = 14 - 9.45 = 4.55$   
 $pOH = 4.55 = -\log [OH^-]$   
 $[OH^-] = 10^{-4.55} = 2.8 \times 10^{-5}M$
76. Answer: D  
When  $K_b$  is given the equilibrium reaction produces  $OH^-$ .
77. Answer: C  
 $H_2SO_4$  is a strong acid and its first step acidic dissociation is complete.  $[H_3O^+]$  is greater than 1.0 M because of the second step partial dissociation.
78. Answer: A  
Highest pH means the least acidic (or the most basic) solution.  $HNO_2$ , and  $NH_4I$  are acids.  $NaI$  is neutral.  $KHCO_3$  is basic.
79. Answer: B  
 $N_2H_4(aq) + H_2O \rightleftharpoons N_2H_5^+ + OH^-$   
 $K_b = (0.010 \times 1.3\%)(0.010 \times 1.3\%)/0.010 = 1.7 \times 10^{-6}$
80. Answer: D  
 $0.0915 \text{ mol NaOH/L} \times 0.0377L \times$   
 $1 \text{ molHX}/1 \text{ mol NaOH} = 0.00345 \text{ molHX}$   
Molar Mass =  $0.483g/0.00345 \text{ mol} = 140g/\text{mol}$
81. Answer: B  
 $Ca(OH)_2$ , therefore  $[OH^-] = 2 \times 0.012 M$   
 $= 0.024M$   
 $pOH = -\log(0.024) = 1.62$   
 $pH = 14 - 1.62 = 12.38$
82. Answer: C  
The solution is a buffer with pH above 7. A buffer is resistant to both addition of strong acid and strong base and the concentration of the hydronium ion is less than the hydroxide ion.
83. Answer: D  
From the  $K_a$  we can see that this is a reasonably strong acid. The titration between a strong acid and a strong base has a pH at the equivalence point about neutral (7) therefore Bromothymol blue should be used as an indicator.
84. Answer: B  
A polyprotic acid will have two different  $K_a$  values and therefore two different equilibrium points.
85. Answer: D  
For this equilibrium  $pH = pK_a + \log \frac{[In^-]}{[HIn]}$   
 $8 = 6 + \log \frac{[In^-]}{[HIn]}$ , therefore  $\frac{[HIn]}{[In^-]} = \frac{1}{100}$
86. Answer: B  
A conjugate acid-base pair only differs by a  $H^+$  ion, therefore  $NH_4^+$  and  $NH_3$  are an acid-base pair.

87. Answer: C



$$K_w = [\text{OH}^-][\text{H}^+] = x^2 = 1.2 \times 10^{-15}$$

$$x = [\text{H}^+] = 3.5 \times 10^{-8} \text{M, therefore}$$

$$\text{pH} = -\log(3.5 \times 10^{-8}) = 7.46$$

**Electrochemistry**

88. Answer: C

A reducing agent gets oxidized, any species that is oxidized loses electrons.

89. Answer: C

In this cell,  $\text{Ag}^+$  is being reduced to  $\text{Ag(s)}$  at the cathode and  $\text{Cu(s)}$  is being oxidized to  $\text{Cu}^{2+}$  at the anode. Current flows from the anode to the cathode. There will be a net movement of copper ions through the salt bridge to the silver half-cell to balance some of the charges.

90. Answer: A

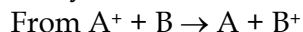
An oxidizing agent gets reduced therefore  $\text{MnO}_4^-$  is the strongest oxidizing agent as it has the largest  $E^\circ$ .

91. Answer: D

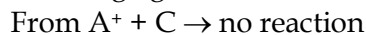
$\text{Cu(s)}$  is at the anode and  $\text{Ag}^+$  is at the cathode. As the cell operates the concentration of  $\text{Cu}^{2+}$  increases as  $\text{Cu(s)}$  is oxidized.

92. Answer: B

Reducing agent undergoes oxidation (most easily oxidized = strongest reducing agent)



B can oxidize to  $\text{B}^+$ ,  $\therefore$  B is a stronger reducing agent than A.



C cannot oxidize to  $\text{C}^+$   $\therefore$  A is a stronger reducing agent than C.



D can oxidize to  $\text{D}^{2+}$   $\therefore$  D is a stronger reducing agent than B.

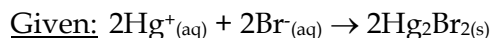
The decreasing order of reactivity (most easily oxidized to least easily oxidized) is:  $\text{D} > \text{B} > \text{A} > \text{C}$ , where D is the strongest reducing agent.

93. Answer: D.

The reactions are classified as follows:

- A. Acid/Base    B. Acid/Base  
C. Precipitation    D. Combustion=Redox

94. Answer: B

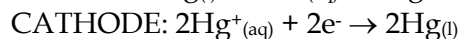
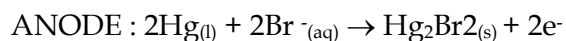


To Find: anode reaction

ANODE allows oxidation to take place, which is the loss of electrons.

- Answers A, C and E are incorrect as they are reduction reactions.

- Answer D is incorrect as the charges on both sides are NOT balanced.

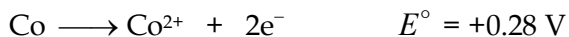


Hg(l) acts as an intermediate

95. Answer: C

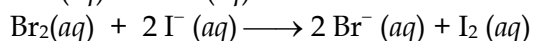
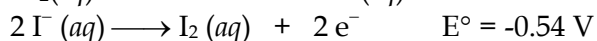
The reducing agent is that which donates electrons (i.e. it loses electrons). In this reaction the reducing agent is  $\text{Fe}^{2+}$  as it loses electrons and becomes  $\text{Fe}^{3+}$ .

96. Answer: B



$$E^{\circ}_{\text{cell}} = 0.28 \text{ V} - 0.13 \text{ V} = 0.15 \text{ V}$$

97. Answer: B



$$E = E^{\circ} - \frac{0.0592}{2} \log Q = 0.55 - \frac{0.0592}{2} \log 2 \times 10^{-4} = 0.66 \text{ V}$$

$\text{Br}_2$  will be reduced and I will be oxidized.

98. Answer: B

Current flows from the anode to the cathode. The species being reduced is at the cathode and the species being oxidized is at the anode, therefore electrons flow from. Right to Left in the external circuit.

99. Answer: A

$$n = \frac{It}{F} = \frac{(5.0 \text{ A})(30 \text{ min} \times 60 \text{ sec/min})}{96485 \text{ C/mol}} = 0.093 \text{ moles e}^{-}$$

$$0.093 \text{ mole}^{-} \times \frac{1 \text{ mol Au(s)}}{3 \text{ mole}^{-}} = 0.031 \text{ moles Au(s)}$$

$$0.031 \text{ mole Au(s)} \times \frac{196.967 \text{ g}}{1 \text{ mol Au(s)}} = 6.1 \text{ g Au(s)}$$

100. Answer: C

$$n_{\text{electrons}} = \frac{It}{F} = \frac{(5.00 \text{ A})(600 \text{ sec})}{96485 \text{ C/mol}} = 0.0311 \text{ moles electrons}$$

$$0.0311 \text{ mol e}^{-} \times \frac{1 \text{ mol M}^{3+}}{3 \text{ mole}^{-}} \times \frac{x \text{ g}}{1 \text{ mol M}^{3+}} = 1.19 \text{ g}$$

$$\text{Molar mass} = x \text{ g/mol} = 114.8 \text{ g/mol}$$