Year 12
Chemistry
2007

SOLUTIONS

Part 1:

1	(b)	11	(a)	21	(c)
2	(a)	12	(a)	22	(c)
3	(a)	13	(c)	23	(d)
4	(b)	14	(b)	24	(d)
5	(d)	15	(c)	25	(d)
6	(c)	16	(b)	26	(b)
7	(d)	17	(d)	27	(b)
8	(d)	18	(a)	28	(d)
9	(a)	19	(b)	29	(d)
10	(a)	20	(b)	30	(c)

(60)

Part 2:

1(a) $Fe(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Fe^{2+}(aq))$
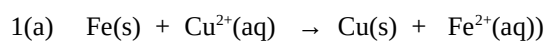
Blue colour of solution fades; salmon coloured solid forms; nail dissolves.   (3)

1(b) $2CH_3CH_2OH(l) + 2Na(s) \rightarrow 2CH_3CH_2O^-Na^+ + H_2(g)$
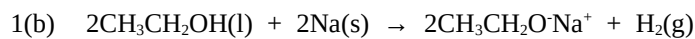
Metal dissolves; colourless odourless gas is given off .   (3)

1(c) $Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \leftrightarrow CoCl_4^{2-}(aq) + 6H_2O(l)$
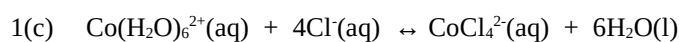
Deep blue solution formed; pink solid dissolves.   (3)

2.   (a)

(b)
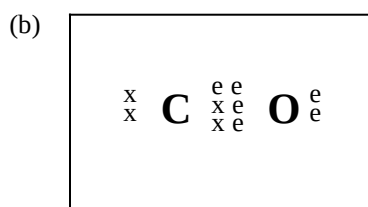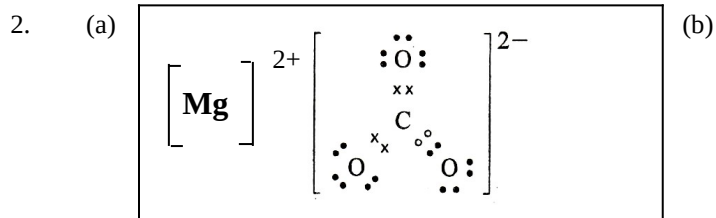
(4)
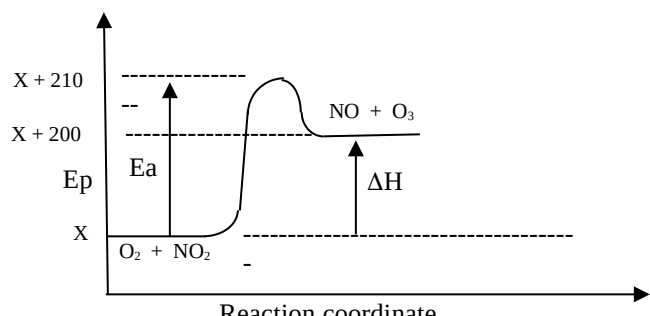
3.   (a) SO_2, F_2O

     (b) BF_3, Br_2, CH_4

     (c) Br_2,   HCN   (6)

4.   (a) $2Cu(NO_3)_2(s) \rightarrow 2CuO(s) + 4NO_2(g) + O_2(g)$ (2)
     (b) $Cu(OH)_2$: Copper(II) hydroxide   (1)
     (c)   Metal displacement or redox   (1)

5   A brown precipitate forms: $2Ag^+(aq) + 2OH^-(aq) \rightarrow Ag_2O(s) + H_2O(l)$
     OR $2Ag^+(aq) + H_2O(l) + 2NH_3(aq) \rightarrow Ag_2O(s) + 2NH_4^+(aq)$
     With excess, the brown precipitate dissolves to form a colourless solution
     $Ag_2O(s) + H_2O(l) + 4NH_3(aq) \rightarrow 2[Ag(NH_3)_2]^+(aq) + 2OH^-(aq)$ (4)

6.   (a)   Alkali metals in Group I have one valence electron and form +1 ions.
           Alkaline earth metals in Group II have two valence electrons and form +2 ions.
     (2)
     (b)   Covalent bonds - when two atoms share a pair of valence energy level electrons.
           Dative covalent bond - when one atom provides both electrons of the shared pair.   (2)

7.   While one would expect HCl's MP to be higher due to stronger dipole-dipole interaction,
           the increase in dispersion force as a result of the size of HI more than compensates for the
           decrease in dipole-dipole force   (2)

8.

                                                                                                            (3)

   The reaction is endothermic.   (1)

9.   (a) $K = [H_2O][CO_2]^2$ (2)
     (b)   Increasing the concentration of carbon dioxide will favour the production of reactants
           OR It decreases concentration of carbon dioxide OR K value stays the same.
     (2)
     (c)   If the volume of the chamber is increased, this decreases the total concentration of particles.
           The system tries to re-establishes equilibrium by favouring the reaction which increases the
           number of particles ie It favours the forward reaction producing more CO_2 and H_2O.   (2)

10. (a) Equation: $2H_2(g) + CO(g) \rightarrow CH_3OH(l) + heat$ (1)

(b) Fast reaction rate is favoured by high temperature, use of catalyst and increasing the concentration of reactants ie increasing the pressure of reactants.

(2)   High equilibrium yield is favoured by high pressure and low temperature.

(2)

11. (a)
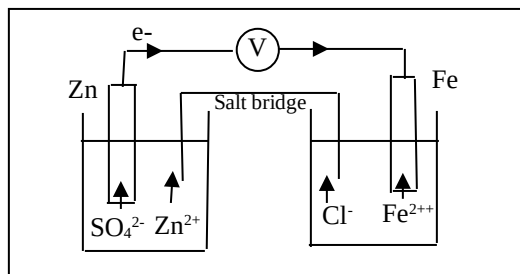
Salt bridge	(1)
e- flow	(1)
ion flow	(1)
correct cell	(1)

(b) Cathode: $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ (1)

Anode: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ (1)

(c) Cell voltage remains the same. The Fe electrode is effectively inert - it doesn't matter what the electrode is - there is no change in the chemical reaction which occurs in the cell. (1)

12. Anode: Bar of silver metal

Cathode: Iron chain

Electrolyte: Silver salt (eg silver nitrate) complexed with cyanide   (4)

13. Sulfuric acid: Contact process: Catalyst used : Vanadium(V) oxide (V_2O_5)

Aluminium: Hall-Heroult process: Catalyst used: Cryolite (Na_3AlF_6)   (4)

14. (a) CH_3COCH_3 (2)

(b) $CH_2BrCHBrCH_3$ (2)

(c) $CCl_3CCl_2CCl_3$ (or any partial substitution products)   (2)

Part 3:

1. (a) $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

OR $Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$ (1)

(b) $n(Pb(NO_3)_2) = m/M = 2/331.22 = 6.0383 \times 10^{-3}$

$n(KI) = m/M = 3/166 = 1.8072 \times 10^{-2}$ (1)

SR $n(KI) / n(Pb(NO_3)_2) = 2/1 = 2$

AMR $n(KI) / n(Pb(NO_3)_2) = 1.80723 \times 10^{-2} / 6.0383 \times 10^{-3} = 2.99$ (1)

AMR > SR   Hence, $Pb(NO_3)_2$ is the limiting reagent   (1)

(c) from the equation, $n(PbI_2)$ prodduced $= n(Pb(NO_3)_2)$ reacted $= 6.038 \times 10^{-3}$ mol. (1)

$m(PbI_2) = n.M = 6.03828 \times 10^{-3} \times 461 = 2.7836$ mol $= \underline{2.78\ g\ PbI_2}$ produced (1)

(d) from the equation, $n(KI)$ reacting $= 2 \times n(Pb(NO_3)_2) = 2 \times 6.038 = 1.208 \times 10^{-2}$ mol (1)

$m(KI)$ reacting $= n.M = 1.208 \times 166 = 2.0047$ g   (1)

$m(KI)$ left over $= m(KI)$ original $- m(KI)$ reacting $= 3 - 2.0047 = 0.9953 = \underline{0.995\ g\ KI}$ (1)

2. (a) $PV = nRT$ Hence, $M = mRT/PV$

   Hence, $M = \rho RT/P = (2.458)(8.31)(288.1)/(101.3) = 58.127$ Hence, $M_r = 58.1$ (1)

 (b) (molecular formula) / (empirical formula) = (relative molecular mass) / (relative E.F. mass)

   Hence, molecular formula $= (58.1)/(29.06) \times (C_2H_5) = 1.999 \times (C_2H_5) = \underline{C_4H_{10}}$ (1)

 (c) $C_4H_{10} + 13/2\ O2 \rightarrow 4CO_2 + 5H_2O$

   $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ (1)

   $n(CO_2) = PV/RT = (101.3)(5)/(8.315)(693.1) = 8.7886 \times 10^{-2}$ (1)

   from equation, $n(C_4H_{10}) = 2/8 \times n(CO_2) = 1/4\ (8.7886 \times 10^{-2}) = 2.1972 \times 10^{-2}$ (1)

   At STP, $V = nRT/P = (2.1972 \times 10^{-2})(8.315)(273.1)/(101.3) = 0.4925$

   Hence, the volume of gas at STP $= \underline{0.493\ L}$ (1)

   $n(H_2O) = 5/4\ n(CO_2) = (1.25)(8.7886 \times 10^{-2}) = 0.1099$ (1)

   $m(H_2O) = n.M = (0.10986)(18.016) = 1.9792 = \underline{1.98\ g\ H_2O}.$ (1)

3. m(hydrated compound) $= 1.684$ g

  m(anhydrous comound) $= 1.383$ g

  $m(H_2O)$ in compound $= 1.684 - 1.383 = 0.301$ g (1)

  $n(H_2O) = m/M = (0.301)/(18.016) = 1.6707 \times 10^{-2}$

  $n(H_2O)$ in $1/3 = (1.6707 \times 10^{-2})/3 = 5.569 \times 10^{-3}$ mol (1)

  $1/3$ m(anhydrous compound) $= (1.383)/(3) = 0.461$ g (in each experiment)

  $n(Ni) = n(NiS) = m(NiS)/M(NiS) = (0.338)/(90.75) = 3.7245 \times 10^{-3}$ mol (2)

  $m(Ni) = n.M = 0.21859$ g

  $n(Cl) = n(AgCl) = m(AgCl)/M(AgCl) = (0.532)/(143.35) = 3.7112 \times 10^{-3}$ mol (2)

  $m(Cl) = n.M = 0.13156$ g

  $n(C) = n(CO_2) = m(CO_2)/(M(CO_2) = 0.082/44.01 = 1.8632 \times 10^{-3}$ mol (2)

  $n(CO_3^{2-}) = n(C) = 1.8632 \times 10^{-3}$ mol.

  Hence, $n(Ni) = 3.7245 \times 10^{-3} \equiv 1.99 = 2.$ $n(Cl) = 3.7112 \times 10^{-3} \equiv 1.99 = 2.$

     $n(CO_3^{2-}) = 1.8632 \times 10^{-3} \equiv 1 = 1.$ $n(H_2O) = 5.569 \times 10^{-3} \equiv 3 = 3.$ (1)

  Hence, the formula of the hydrate is $Ni_2Cl_2CO_3 . 3H_2O$

  <u>Hence, w = 2, x = 2, y = 1, and z = 3</u> (1)

4. (a) The titre volumes are: 26.65, 25.21, 25.11, and 25.29 mL. The first value is outside the

   acceptable range of +/- 0.2 mL. Hence, average titre $= 25.203$ mL. (1)

   $n(S_2O_3^{2-}) = c.V = (0.5)(0.0252) = 0.01260$ mol. (1)

   from the equation, $n(I_2) = 1/2\ n(S_2O_3^{2-}) = 1/2\ (0.01260) = 0.0063$ mol I_2 (1)

   from the equation, $n(OCl^-) = n(I_2) = 0.0063$ mol. (1)

   $c(OCl^-) = n/V = (0.0063)/(0.02) = \underline{0.315\ mol\ L^{-1}}$ (1)

 (b) $n(NaOCl) = n(OCl^-) = 0.0063$ mol.

   $m(NaOCl) = n.M = (0.0063)(74.44) = 0.469034$ g (1)

   $\rho(bleach) = m/V$ Hence, m(bleach) $= \rho.V = (1.03)(20) = 20.6$ g (1)

   %(NaOCl) $= [m(pure)/m(impure)] \times 100 = [(0.46903)/(20.6)] \times 100 = 2.27686$

   <u>Hence, the bleach is 2.28% by mass sodium hypochlorite</u> (1)

5. (a) $n(Cu) = m/M = (3.26)/(63.55) = 0.051298$ (1)

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

From the equation, $n(e^-) = 2 \times n(Cu) = (2)(0.051298) = 0.10260$ mol.   (1)

At the anode of Cell 2, $Al \rightarrow Al^{3+} + 3e^-$

$n(Al) = 1/3\, n(e^-) = 1/3\,(0.10260) = 0.03420$ mol   (1)

$m(Al) = n.M = (0.03420)(26.98) = 0.92268$ g

Hence, the change in mass of the anode of Cell 2 is 0.923 g   (1)

(b)   Cell 1 Anode: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

$n(O_2) = 1/4\, n(e^-) = (0.1026)\,/\,(4) = 0.02565$ mol   (2)

Cell 2 Cathode: $H_2O + 2e^- \rightarrow H_2 + 2OH^-$

$n(H_2) = 1/2\, n(e^-) = (0.1026)\,/\,(2) = 0.05130$ mol   (1)

Hence, $n(gas) = n(H_2) + n(O_2) = 0.0513 + 0.02565 = 0.07694$ mol   (1)

$PV = nRT$ Hence, $V = nRT\,/\,P = (0.07695)(8.315)(298.1)\,/\,(99.8) = 1.9105$ L = 1.91 L   (1)

(c)   Since $Q = It$, and $n(e^-) = Q\,/\,(9.649 \times 10^4)$, $Q = n(e^-)(9.649 \times 10^4) = 9899$ C   (1)

$I = Q/t = (9899)\,/\,(90 \times 60) = 1.8332 = 1.83$ A   (1)

Part 4:   Note: Not every point needs to be mentioned to score full marks.

Physical properties of oxalic acid   (maximum 7 marks)

In $H_2C_2O_4$, all elements are nonmetals hence it has only covalent bonding and forms covalently
bonded molecules.

Oxalic acid has relatively low melting and boiling points since the forces between molecules
are weak.

Oxalic acid will not conduct in the solid or molten states since molecules are uncharged and
electrons are localised.

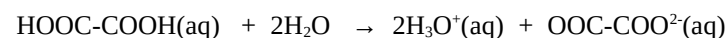Oxalic acid molecules are polar, hence it is soluble in polar solvents.

Oxalic acid has similar intermolecular forces as in water, hence it is very soluble in water.

Oxalic acid is insoluble in non-polar solvents such as benzene.

Properties of $H_2C_2O_4$ as an acid   (maximum 7 marks)

As an acid, oxalic acid donates protons:

 $HOOC\text{-}COOH(aq) + 2H_2O \rightarrow 2H_3O^+(aq) + OOC\text{-}COO^{2-}(aq)$

Oxalic acid is diprotic - it contains 2 ionisable hydrogens per molecule.

Oxalic acid is weaker than inorganic acids such as HCl, H_2SO_4, but stronger than organic counterparts.

Oxalic acid is stronger than ethanoic acid because it has more highly electronegative atoms (oxygens)
attached to the carbon chain, and it has more ionisable hydrogen atoms than ethanoic acid.

As an acid, oxalic acid:

        turns blue litmus red

        tastes sour (though it should not be tasted!)

        reacts with reactive metals to produce hydrogen gas

        reacts with carbonates and hydrogencarbonates to form carbon dioxide , water and a salt

        neutralises bases (metal oxides and metal hydroxides).

As an organic acid, it also undergoes :

        Esterification: An acid catalysed reaction between this acid and an alcohol. The

        hydrogen of the alcohol and the hydroxyl group of the acid combine to form water .

The remaining carbonyl groups combine.

Condensation polymerisation: As a dicarboxylic acid it can react with a diol to form a

polyester.

It can also react with diamines to produce polyamides.
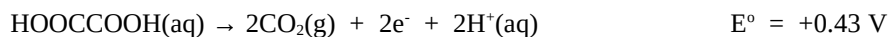

Oxalic acid's role in redox reactions: (maximum 6 marks)

Oxalic acid is a good primary standard - it is obtainable in very pure form, does not alter weight

during weighing, and has a relatively high formula mass.

It is used in the laboratory to standardise other solutions eg $KMnO_4$ (aq).

As a reducing agent, it helps other substances get reduced, and is itself oxidised:

$HOOCCOOH(aq) \rightarrow 2CO_2(g) + 2e^- + 2H^+(aq)$ $E^o = +0.43$ V

END OF SOLUTIONS