ADVANCED LEVEL CHEMISTRY NATIONAL EXAMINATION PAPER 2020-2021 answers

SECTION A:

1) **Answer:**
   a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
   b) **Manganese is considered to be a transition metal because:**
      - ✓
      - ✓ **Has ions with partially filled d-orbital**
      - ✓ **It has multiple oxidation states**
      - ✓ **It forms coloured compounds**
   c) Mn^{2+} **has a half filled d-orbital which is stable structure**
2) **Answer:**
   a) **i) The first ionization energy is the energy required to remove the most loosely held electron from one mole of neutral gaseous atoms to produce 1 mole of gaseous ions each with a charge of 1+.**
      ii) Factors affecting first ionization energy
      - ✓ **<u>Size of atom</u>: as the number of energy levels (shells) increases, the force of attraction between the nucleus and valence electron decreases, heance the ionization energy decreases with increase in atomic size.**
      - ✓ **<u>Nuclear charge</u>: The nucleus charge is the total charge of all the protons in the nucleus. As the nucleus charge increases, the force of attration between nucleus and valence electrons on the same valence energy leve increases, hence the higher the ionization energy.**

   b) **i) Electronegativity is measure of the tendancy an atom to attract to itself the shared pair of electons making bond.**
      ii)
      - **Nuclear charge**: electronegativity increase with increasing nuclear charge.
      - **Atomic size**: electronegativity decreases with increase in size of atom.
      - **Screening effect**: increase in number of inner electrons tends to decrease the electronegativity due to screening effect,

3) **Answer:**
   a) $1s^2 2s^2 2p^6$
   b) $Mg^{2+} < Na^+ < F^-$
4) **Answer:**
   a) **NaF: ionic bond;** H_2S **has got covalent bond**
   b) **Covalent compounds (for this case** H_2S**) exist as individual molecules, held together by weak van der Waals forces hence low melting point, while the melting point of ionic compound (here NaF) is higher due to strong electrostatic forces between oppositely charged ions in NaF hence melting point of NaF is higher than that to** H_2S
5) **Answer:**

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a) $E^{o}cell = E\ cathode - Eanode = 0.34V - (-1.18V) = 1.52V$

b) $Mn(s) + Cu^{2+}(aq) \rightleftarrows Mn^{2+}(aq) + Cu(s)$

$Qc = \frac{[Mn^{2+}]}{[Cu^{2+}]}$

c)

Galvanic cell	Electrolytic cell
It converts chemical energy into electrical energy	It converts electrical energy into chemical energy.
It is based upon the redox reactions which are spontaneous	The redox reactions are non-spontaneous and take place only when energy is supplied
The chemical changes occurring in the two beakers are different.	On one chemical compound undergoes decomposition
The two half cells are set up in different containers and are connected through salt bridge or porous partition.	Both the electrodes are placed in the solution or molten electrolyte in the same container
✓ Anode (-ve): Oxidation takes place ✓ Cathode (+ve): reduction takes place	✓ Anode (+ve): oxidation takes place ✓ Cathode (-ve): reduction takes place

6) Answer:

a) Molar concentration of $CaCl_2 = \frac{0.089g/l}{111mol/l} = 8.02x10^{-4}mol/l$

Molar concentration in $mol/cm^3 = 8.02x10^{-4}mol/dm^3 = 8.02x10^{-7}mol/cm^3$

Molar conductivity $= \frac{2.69x10^{-4}ohm^{-1}cm^{-1}}{8.02x10^{-7}mol/} = 335\ Ohm^{-1}\ cm^2\ mol^{-1}$

b) $\Lambda_{mCaCl_2} = \Lambda_{mCa^{2+}} + 2\Lambda_{mCl^-}$

$\Lambda_{mCl^-} = \frac{1}{2}(335 - 104)ohm^{-1}cm^2mol^{-1} = 115.5\ ohm^{-1}cm^2mol^{-1}$

7) Answer:

a) i) A complex ion is a chemical species made of a central metal (cation or neutral) bonded to other chemical species called ligands by coordination or dative bonds.

ii) Transition metals form complexes because of:

- ✓ They are small and are highly charged ions
- ✓ They have vacand d-orbitals (empty) which can accommodate lone pair of electrons donated by other groups (ligands).

b) i) Oxidation state of Fe in $[Fe(CN)_6]^{3-}$

Let x be the oxidation state of Fe;

X + 6(-1) = -3

X = -3 +6 = +3

Oxidation state of Fe is +3

Oxidation number of Cu in $[CuCl_4]^{-2}$

X + 4(-1) = -2

X = -2+4 = +2

Oxidation number of Cu is +2

ii) The coordination number of iron is six

8) Answer:

a) Propan-1-ol has stronger H-bond than H-bond in 1-aminopropane because O atom has higher electronegativity than N atom.

b) Phenol is more acidic than phenyl methanol because lone pair on oxygen atom is involved in delocalization of pi electrons in benzene ring and hence the O-H is weakened and more H ions are easily released in solution.

c) $BeCl_2$ is soluble in ethanol beause it is covealent compound while $MgCl_2$ is ionic which is soluble in water and less soluble in ethanol.

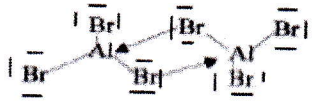
9) Answer:

a) $[H^+] = \sqrt{Ka\ x\ Ca} = \sqrt{1.3x10^{-5}x0.1} = 1.14x10^{-3}M$

b) $pH = -\log[H^+] = -\log 1.14x10^{-3} = 2.94$

10) Answer:

a)

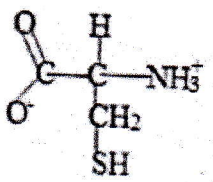


b) According to the Lewis theory $AlBr_3$ is Lewis acid because it has an empty orbital to accept the lone pair of electrons by coordination bond.

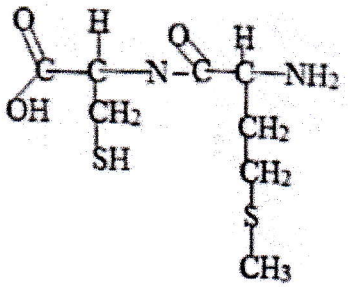
c) $MgBr_2$ is ionic compound because Mg has less electronegativity, so it loses electrons to Br of high electronegativity, while the Al has small size and highly charged with high polarizing power wich gives it ability to distory electron cloud from Br and share electrons to form bond tending to be covalent.

11) Answer:

a)



b)



12) Answer:

a) $CH_3CH_2CH_2C\equiv CH$

b) $CH_3CH_2CH_2\equiv CH$: Pentyne; $CH_3CH(CH_3)C\equiv CH$: 3-methylbutyne

c) $CH_3CH_2CH_2C\equiv CH + 2HBr \rightarrow CH_3CH_2CH_2CBr_2CH_3$

13) Answer:

a) I_2 is sparingly soluble in water because is non-polar and insoluble in water, but I_2 dissoloves in aqueous KI because I_2 reacts with I^- to form I_3^- which polar and soluble in polar solvent such as water

b) HF has higher boiling point than HCl because HF has got strong H-bond with other HF molecules which is absent in HCl with dipole dipole intermolecular force which is weaker than H-bond in HF, hence HF has higher boiling point.

14) Answer:

$$x = \frac{\frac{m}{Mm}}{\frac{m_{H_2O}}{Mm} + \frac{m}{Mms}} = \frac{\frac{114}{Mm}}{\frac{1000}{18}} = \frac{2.052}{Mm}$$

Note that $nH_2O >>> ns$, hence $n_{tot} \approx nH_2O$

$$x = \frac{\Delta P}{Pwater} = \frac{17.54 - 17.435}{17.54} = \frac{2.052}{Mm} = 0.00599$$

Mm = 2.052/0.00599 = 342.57g/mol

15) Answer:

a) $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

n HCl = MxV = 0.022 x 0.0182 = $4x10^{-4}$mol

$nOH^- = 4x10^{-4}$mol

b) $Ksp = [Ca^{2+}]x[Cl^-]^2 = S \times (2S)^2$

$Ksp = 4xS^2 = 4x(2x10^{-4})^3 = 3.2x10^{-11}$

SECTION B: Attempt three questions only (30 marks)

16) Answer:

a) i) OH^- hydroxyl functional group of alcohol (Or R-OH)

ii) Ester functional group

b) –CHO: aldehyde functional group

c) $HOCH_2CHO$

d)

e) HOOC-COOH

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f) $HOCH_2CH_2OH$

g) CH_2BrCH_2Br

17) Answer:

a) With respect to NO: $r = k[NO]^x[Cl]^b$

$$\frac{r1}{r2} = \frac{(0.03)^x}{(0.015)^x} x \frac{(0.01)^y}{(0.01)^y}$$

$$\frac{3.4x10^{-4}}{8.5x10^{-5}} = 2^2 = 2^x$$

$$x = 2$$

With respect to Cl_2

$$\frac{r_3}{r_2} = \frac{3.4x10^{-4}}{8.5x10^{-5}} = \frac{(0.04)^y}{(0.01)^y}$$

$$4 = 4^y$$

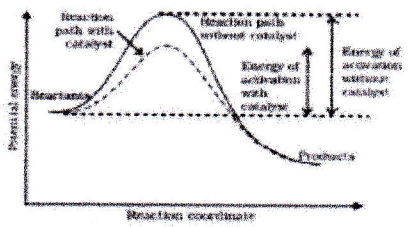
$$y = 1$$

b) $r = k[NO]^2[Cl_2]^1$

c) $k = \frac{r}{[NO]^2[Cl_2]^1} = \frac{3.4x10^{-4} moldm^{-3} sec^{-1}}{0.03 moldm^{-3} x (0.03 moldm^{-3})(0.01 moldm^{-3})} = 37.778 mol^{-2}dm^6sec^{-1}$

d) The temperature increases the number of collisions with sufficient energy to react hence increasing the rate of reaction.

e) The catalyst provides an alternate pathway or reaction mechanism by reducing the activation energy between reactants and products, hence lowering the potential energy barrier.



18) Answer:

a) Both form covalent compounds and both Be and Al form complex ions

b) The solubility of MSO_4 decreases down the group due to the decrease of hydration energy.

c) Ecathode – Eanode = -0.44V – (- 2.37) V = 1.97V
Mg forms magnesium oxide which protects iron

d) White prectipitate is formed and green colour of aqueous solution disappears.

e) It can be used in the manufacture of aircraft's components.

19) Answer:

a)

b) i) $P_A = X_A \times P^o_A$

$$P_A = \frac{1}{1+4} x 10kPa = 2kPa$$

ii) $P_B = \frac{4}{1+4} x12.5kPa = 10kPa$

iiii) $P_{tot} = P_A + P_B = (2+10)kPa = 12kPa$

c) Mm of solid = N_A x mass = 6.02 x 10^{23} x 1.1 x 10^{-19} = 6.622x 10^4 g/mol

$M = \frac{60g/l}{6.622x10^4} = 9.06x10^{-4}$ mol/l

$\Pi = \frac{9.06x10^{-4}mol}{l} x0.0823l.\frac{atm}{molxk} x\ 298k = 2.22x10^{-2}$ atm

20) Answer:

a) Number of moles of $S_2O_3^{2-}$ = MxV = $0.5\frac{mol}{l} x0.02l = 0.01mol$

b) n $I_2 = \frac{0.01}{2} = 0.005moles$

c) i) number of moles of Cu^{2+} in 20ml = 2x5x10^{-3}mol = 0.01mol

ii) number of moles of Cu^{2+}in 200ml = $\frac{0.01x200}{20} mol = 0.1\ mol$

d) Mass of Cu reacted = 63.5g/mol x 0.1mol = 6.35g

e) % Cu = $\frac{6.35}{6.5} x100 = 97.69\%\ of\ Cu$

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