THE UNITED REPUBLIC OF TANZANIA
PRESIDENT 'S OFFICE
REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

STRIVE TO EXCEL
SYNDICATE

FORM SIX SPECIAL SCHOOL JOINTS EXAMINATION

132/1 **CHEMISTRY 1 MARKIMG SCHEME**

1. (a) (i) Three (3) postulates and (3) shortcomings of Bohr's hydrogen model.

Postulates of Bohr's atomic model

- Electrons revolve around the nucleus in discrete circular permissible paths called orbits.
- When revolving in its orbital an electron neither radiates nor absorbs energy.
- In its orbit, the angular momentum of a revolving electron is quantized and given by mvr = $\frac{nh}{2\pi}$ where (1, 2, 3…..)
- When electrons lose energy, they shift to lower energy levels and when they absorb energy they shift to higher energy levels.

Any 3 postulates @ $\frac{1}{2}$ ***mark total 01***$\frac{1}{2}$ ***marks***

Shortcomings of Bohr's atomic model

- It could not explain about the spectrum of multielectron atoms.
- It could not explain about the nature of chemical bonding.
- It could not explain convincingly about the way of quantization of angular momentum.
- It could not offer explanations on the splitting of spectral lines in magnetic and electric fields.
- Could not account for the shapes of molecules.
- It failed to explain about multiple spectra lines structure.

Any 3 shortcomings @ $\frac{1}{2}$ ***mark total 01***$\frac{1}{2}$ ***marks***

(ii) Spacing between lines in the hydrogen spectrum decrease as one goes away from the nucleus because the energy difference between energy levels decreases as one goes away from the nucleus, thus higher energy levels have almost the same energy since they experience lesser nucleus attractive forces. **(1mark)**

(b) Given that:

Higher energy level $n_2 = \infty$

lower energy levels, $n_1 = 3$ (Paschen series).

(i) Required frequency of radiations emitted;

Solution

From Rydberg equation : $\frac{1}{\lambda} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

But $n_1 = 3$ and $n_2 = \infty$

Then $\frac{1}{\lambda} = R_H \left[\frac{1}{3^2} - \frac{1}{\infty^2}\right]$

$\frac{1}{\lambda} = 1.09678\times10^7\ m^{-1} \left[\frac{1}{3^2} - \frac{1}{\infty^2}\right]$

$\frac{1}{\lambda} = 1.21864 \times 10^6\ m^{-1}$

$\lambda = 8.20587 \times 10^{-7} m$

but frequency $v = \frac{c}{\lambda} = \frac{3 \times 10^8 ms^{-1}}{8.20587 \times 10^{-7} m}$ **= 3.65592 x 10^{14} Hz** **1mark**

(i) Required energy possessed by the electron in the new energy level/shell:

From:

Energy possessed by electron in **n** energy level = $\frac{-13.6ev}{n^2}$

But n = 3 and 1ev = 1.6 x 10^{-19}J

Then Energy = $\frac{-13.6 \times 1.6 \times 10^{-19}}{3^2}$

Energy = -2.418× $\mathbf{10^{-19}}$ J

Hence the energy of electron in new shell is **-2.418× $\mathbf{10^{-19}}$ J** **1 mark**

Required energy emitted during transition:

Energy emitted = E_∞ - E_3

Energy emitted = $\frac{-13.6ev}{\infty^2}$ - $\frac{-13.6 \times 1.6 \times 10^{-19}}{3^2}$

Energy emitted = **2.418× $\mathbf{10^{-19}}$ J** **1mark**

(c) Name of a geometrical structure and one example of the molecule formed from the following types of hybridized atomic orbitals.

(i) sp hybridized orbitals:

Molecules shape is Linear **½ marks**

Example : $BeCl_2$, C_2H_2 and CO_2 **½ marks**

(ii) sp^2 hybridized orbitals:

molecular shape: Trigonal planar **½ marks**

Examples: BCl_3 and $AlCl_3$ **½ marks**

(iii) Sp^3 hybridized orbitals:

Molecules shape: Tetrahedral(tetrahedron) **½ marks**

Example is CH_4**, and** NH_3 **½ marks**

TOTAL OF 10 MARKS

2. (a)

(i) Soil pollutant-is any factor which deteriorates the quality, texture and mineral content of the soil and disturb the biological balance in it and has lethal effects on plant growth.

(ii) Greenhouse effect- Is the warming of the earth or global warming due to re-emission of sun's energy absorbed by the earth followed by its absorption by carbon dioxide and water vapour present near the earth and then radiated back to the earth.

(iii) Contaminant-Is a substance which does not occur in nature but is introduced by human activity into the atmosphere affecting its composition

(@ **01mark = 03 marks)**

(b)

(i) Ozone layer formation

Ozone layer is formed in the atmosphere by decomposition of oxygen by Ultra-violet radiations from the sun having shorter wavelength i.e **(01 mark)**

$O_{2\,(g)} + hv\text{ (uv-light)} \rightarrow O°_{(g)} + O°_{(g)}$ **(00½ mark)**

$O°_{(g)} + O_{2\,(g)} + \text{uv-light} \rightarrow O_{3\,(g)}$ **(00½ mark)**

(ii) Ozone layer depletion by CFCs

When CFCs such as $CFCl_3$, CF_2Cl_2, CF_3Cl are released into the stratosphere, they get broken by uv-radiations releasing Cl free radical. Consider CF_2Cl_2

(00½ mark)

$CF_2Cl_2\text{ (g)} + \text{uv radiations} \rightarrow CF_2Cl°\text{ (g)} + Cl°\text{ (g)}$ **(00½ mark)**

The free radical Cl° reacts with ozone (O3) through a chain reaction

$Cl°\text{ (g)} + O_3\text{ (g)} \rightarrow ClO°\text{ (g)} + O_2\text{ (g)}$ **(00½ mark)**

$ClO°\text{ (g)} + O\text{ (g)} \rightarrow Cl°\text{ (g)} + O_2\text{ (g)}$ **(00½ mark)**

The chlorine free radical are free to react with more ozone as a result many O_3 molecules are destroyed

(c) Effects of acidic rain

- Extensive damage to the buildings and sculptural materials of marble, limestone etc
- Affects plants and animals life in aquatic ecosystem
- Corrodes metals and damage iron and steel structure
- It is harmful to agriculture as it washes away nutrients needed for plant growth
- It dissolves heavy metal from the soil, rocks, and sediments et.

(Any 3 points @ 00½ mark = 01½ mark)

Methods of reducing acidic rain

- Using fossil fuel with less Sulphur content in power plants and industries
- Having less vehicles driven by fossil fuels
- Using catalytic convertor in cars
- Using powdered limestone to neutralize the acidity of the soil

(Any 3 points @ 00½ mark = 01½ mark)

3. (a) (i) Ideal gas
    - High temperature/above critical temperature
    - Low pressure/below critical pressure

  (ii) Boyle's law
    - Fixed mass of a gas
    - Constant temperature

  (iii) Dalton's law of partial pressure
    - Non reacting gases
    - Constant temperature

(@ 00½ mark = 03 mark)

Faults assumptions of kinetic theory of gases

- The volume occupied by gas molecules is negligible
- The forces of attraction between gas molecules are negligible

(@ 01 mark = 02 mark)

Data given

$mass\ of\ oxygen = 0.02g\ in\ 100\ \text{cm}^3$

$volume\ of\ blood\ in\ the\ body = 10\ litres = 10000\ \text{cm}^3$

$mass\ of\ oxygen\ in\ 10{,}000cm^3$

$0.02g \quad \rightarrow \quad 100\ \text{cm}^3$

$x \quad \rightarrow \quad 10{,}000\ \text{cm}^3$

$$x = \frac{0.02\ x\ 10{,}000}{100}$$

$$x = 2\ g \qquad (\ \mathbf{01}\ \boldsymbol{marks})$$

Mass of oxygen in the blood = 2 g

$mass\ of\ carbon\ dioxide\ in\ the\ blood$

$0.08g \quad \rightarrow \quad 100\ \text{cm}^3$

$x \quad \rightarrow \quad 10{,}000\ \text{cm}^3$

$$x = \frac{0.08\ x\ 10{,}000}{100}$$

$$x = 8\ g \qquad (\ \mathbf{01}\ \boldsymbol{marks})$$

Mass of carbon dioxide in the blood = 8 g

From ideal gas equation

$V = \frac{nRT}{P}$

For oxygen

$V = \frac{mRT}{MP} \quad = \frac{2 \, x \, 0.0821 \, x \, 310}{32 \, x \, 1}$ ($\mathbf{00½} \; \boldsymbol{marks}$)

$= 1.59 \; dm3$ ($\mathbf{01} \; \boldsymbol{marks}$)

For carbon dioxide

$V = \frac{mRT}{MP} \quad = \frac{8 \, x \, 0.0821 \, x \, 310}{44 \, x \, 1}$ **(00½ marks)**

$= 4.62 \; dm3$ ($\mathbf{01} \; \boldsymbol{marks}$)

4. (a) (i) Cryoscopic constant is the depression of the of the freezing point of the solvent in the solution which is obtained when one mole of the non-volatile solute is dissolve in 1kg (1000g) of the solvent while ebullioscopic constant is the boiling point elevation of the solvent in the solution which is obtained when one mole of non-soluble solute is dissolved in 1kg (1000g) of the solvent.

(ii) Boiling point of the substance is the temperature at which the vapour pressure of the substance is equal to the atmospheric pressure while the vapour pressure is the pressure exerted by the vapour on the liquid surface.

(iii) The effect is that when the degree of dissociation is high more solute particle will go the solution leading to higher boiling elevation hence the boiling point of the solution will be high.

1mark@ total = 3marks

(b) from ΔT = Kf x molarity .... I ½ marks

But Molarity = $\frac{m_s}{M_s \; x \; m_{sv} mkg}$ .... ii ½ marks

Substituing (ii) into (i) gives

ΔT = Kf x $\frac{m_s}{M_s \; x \; m_{sv} mkg}$

Then

$M_s = \frac{\Delta T \; x \; M\_(s) \; x \; m\_sv \; mkg}{kf}$ ½ marks

$\Delta T = 0.0^0C - (-23.3^0C) = 23.3^0C$

$M_s = 62.0gmol^{-1}$

msv = $1gmol^{-1}$ x 10 x 10^3ml = 1 x 10^4g

kf = 1.86 $Ckgmol^{-1}$

ms = $\frac{23.3 \; x 62 \; x 1 x 10^4}{1.86}$ ½ marks

ms = 7.767kg

<u>Therefore, the mass of ethylene glycol is 7.767kg</u> 2mark

(c) From πv = nRT 1 mark

But n = $\frac{m_s}{M_r}$

Then $\pi v = \frac{m_s}{M_r}$RT

$M_r = \pi v = \frac{m_s}{\pi v}RT$

$T = 20^0C = 293K$

$n = 8.31Jmol^{-1}K^{-1}$

$\pi = 25.6Pa$

$V = 200cm^3 = 200 \times 10^{-6}m^3$

Then Molar mass (M_r) = $\frac{0.2 \, x \, 8.31x \, 293}{25.6x \; 200x \; 10^{-6}}$ 1mark

<u>Molar mass (M_r) = 5.707×10^4 $gmol^{-1}$</u> 1mark

5. (a)

$2B_{(s)} + 3/2O_{2\,(g)} \rightarrow B_2O_{3(s)}$ $\Delta H = -1273kJ$

$B_2H_{6(s)} + 3O_{2(g)} \rightarrow B_2O_{3(s)} + 3H_2O_{(g)}$ $\Delta H = -2035kJ$

$H_{2(g)} + .O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H = -286$ kJ

$H_2O_{(l)} \rightarrow H_2O_{(g)}$ $\Delta H = 44$ kJ

Reverse equation (ii)

Multiply equation (iii) by 3 on both sides

Add the resulting equations

$+[B_2O_{3(s)} + 3H_2O_{(g)} \longrightarrow B_2H_{6(s)} + 3O_{2\,(g)}$ $\Delta H = +2035KJ$

$[3H_{2(g)} + \frac{3}{2}O_{2(g)} \longrightarrow 3H_2O_{(g)}$ $\Delta H = -858$ KJ

$2B_{(s)} + 3O_{2\,(g)} + 3H_{2(g)} \rightarrow B_2O_{3(s)} + 3H_2O_{(l)}$ $\Delta H = 1273kJ$

Multiply by 3 on both side in equation (iv)

$3H_2O_{(l)} \rightarrow 3H_2O_{(g)}$ $\Delta H = 132$ kJ

Then addition of all the equation give the overall equation

$2B_{(s)} + 3H_{2(g)} \longrightarrow B_2H_{6(s)}$ $\Delta H = +36$ kJ

(b) Required

$CuSO_4(s) + 5H_2O\ (l) \longrightarrow CuSO_4\ 5H_2O\ (s)$

given

$CuSO_4\ (s) + aq \longrightarrow CuSO_4\ (aq)$ = -66.5 kJ ....(i)

$CuSO_4\ 5H_2O\ (s) + aq \longrightarrow CuSO_4\ (aq)$ = -11.7 kJ............(ii)

Then;

using thermochemical equation

$$\begin{tikzcd}
CuSO_4\ (s) \arrow[rr, "H_1"] \arrow[dr, "H_2"'] & & CuSO_4\ (aq) \\
& CuSO_4\ 5H_2O\ (s) \arrow[ur, "H_3"'] &
\end{tikzcd}$$

$\Delta H_1 = \Delta H_2 + \Delta H_3$

$-66.5kJ = \Delta H_2 + 11.7$ kJ

$\Delta H_2 = -78.2$ kJ

(05marks)

6. (a) Three (3) classes of metal oxides

- Basic metal oxides
- Amphoteric metal oxides
- Mixed metal oxides

Explanation @ **00½ marks = 01½marks**

Mentioning @ **00½ marks = 01½marks**

(b)

(i) A chemical test to distinguish soluble Metal Carbonates from metal hydrogen carbonates is magnesium sulphate solution which reacts with soluble metal carbonates to form white precipitates of magnesium carbonates while metal hydrogen carbonates forms a solution of magnesium hydrogen carbonate

CO_3^{-2} (aq) + Mg^{+2} (aq) → $MgCO_3$ (s) white ppt

HCO_3^- (aq) + Mg^{+2} (aq) → Mg $(HCO_3)_2$ (aq)

(ii) Preparation of insoluble metal sulphates

Insoluble metal carbonates are being prepared by precipitation by addition of soluble carbonates to a solution of salt of a less reactive metal

Eg Na_2CO_3 (aq) + $ZnSO_4$ (aq) → $ZnCO_3$ (s) + Na_2SO_4 (aq)

(iii) Strong heating Iron (II) sulphate

This results into formation of a reddish brown solids of Iron (III) oxide and Sulphur trioxide and Sulphur dioxide gas

$2FeSO_4$ (s) $\xrightarrow{\Delta}$ Fe_2O_3 (s) + SO_3 (g) + SO_2 (g)

White *reddish brown*

(iv) Acidity property of aqueous aluminium Chloride

Is due to its ability of undergoing hydrolysis to form hydroxonium ions which is responsible for its acidity property

$AlCl_3$ (aq) + $6H_2O$ (l) → $[Al(H_2O)_6]^{3+}$ + $3Cl^-$ (aq)

$[Al(H_2O)_6]^{3+}$ (aq) + H_2O (l) → $[Al(H_2O)_5OH]^{2+}$ (aq) + $\mathbf{H_3O^+}$ (aq)

(@ **01 marks = 04marks)**

(c) Differences between aluminium chloride and sodium chloride

Aluminium chloride	Sodium chloride
Covalent in nature	Ionic in nature
Dimerizes in vapour state	Does not undergo dimerization in vapour state
Its acidic in aqueous solution	Its solution is neutral
Does not conduct electricity in its molten state	It conducts electricity in its molten state
Undergoes hydrolysis when reacted with water	Dissociates into its ions when reacted with water

(Any 3 points @ 01 marks = 03 marks)

7. (a).

(i) The boiling point of water, ethanol and ethoxyethane (diethyl-ether) are in the reverse order of their relative molecular masses since the molecular forces of attraction are in reverse order of their relative molecular masses. Water and ethanol form hydrogen bonds but hydrogen bond of water are stronger than those of ethanol, diethyl ether has only polar interactions which are less strong than hydrogen bonds. Unlike those of their analogous sulphur compounds, H_2S, C_2H_5SH, $C_2H_5SC_2H_5$ have no effects of hydrogen bonding hence their boiling points increase with molar masses.

(ii) BF_3 is non-polar because its molecule has zero net dipole moment in its structure. Its geometrical structure is Trigonal planar but NF_3 due to an extra lone pair is tetrahedral and it has a net dipole moment, and so it's polar.

(iii) Aluminium fluoride has a much higher melting point than aluminium chloride. This is because the Al- f bond is stronger than the Al- Cl bond due to a higher electronegativity of F compared to that of Cl. This high electronegativity of F polarizes the Al-F bond making it more ionic. Since the Al-f unit is polarized, it results to stronger intermolecular forces between AlF_3 species. This makes their separation (through melting) require more energy than it is required. **@ 1mark total 03marks**

(b). Given: X, Y and Z represent elements of atomic number 9,19 and 34.

(i) Electronic configuration of:

X (9electrons) $=1s^2 2s^2 2p^5$

Y (19 electrons) $=1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Z (34 electrons) $= 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$ @= $0\frac{1}{2}$mark

(ii) Type of bonding expected to occur between:

-X and Y is ionic bonding

-X and Z is covalent bonding

- Y and Z is ionic bonding @ = $0\frac{1}{2}$mark

(iii). X=F, Y=K and Z = Se

KF(X-Y) is an ionic solid. It dissolves in water, it is not volatile and does not conduct electricity unless in aqueous form. SeF_2(X-Z) is a covalent compound. It is more water soluble than KF. SeF_2 does not conduct electricity. **(01mark)**

(c) The effect of hydrogen bonding on:

- Boiling point: Hydrogen bonding increases the boiling points of a compound.

-Solubility of a compound tends to increase with hydrogen bonding since it encourages formation of intermolecular attractive forces between solvent and solute molecules.

@effect = $01\frac{1}{2}\, marks\ \boldsymbol{total} = \boldsymbol{03marks}$

SECTION B (30 MARKS)

8. (a) Le-Chatellier's principle

States that; *when a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium shifts to counteract the change to re-establish an equilibrium*

(01 mark)

For maximum yield ammonia

- Increase in concentration of N_2 and H_2
- Increase in pressure of a system
- Decrease in temperature
- Addition of a catalyst

(Any 4 points @ 01 marks = 04 marks)

(c) The balanced equation

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

$$Kc = \frac{[SO_3]^2}{[SO_2]^2\ x\ [O_2]}$$ **(01 marks)**

(i) Since the number of moles are equal, $[SO_3] = [SO_2] = x$

$$Kc = \frac{[x]^2}{[x]^2\ x\ [O_2]}$$

$$[O_2] = \frac{x^2}{x^2\ x\ Kc}$$

$$[O_2] = \frac{x^2}{x^2\ x\ 100}$$

$$[O_2] = 0.01\ mol/L$$ **(01 marks)**

But n_{O2} = molarity x volume (dm^3)

= 0.01M x 10L

= 0.1 moles **(01 marks)**

(ii) Let the moles of SO_2 = y

Moles of SO_3 = 2y

Therefore; $[SO_3] = \frac{2y}{10}$; $[SO_2] = \frac{y}{10}$; $[O_2] = ?$

$$Kc = \frac{[SO_3]^2}{[SO_2]^2\ x\ [O_2]}$$

$$100 = \frac{[2y]^2}{[y]^2\ x\ [O_2]}$$

$$[O_2] = 0.04\ mol/L$$

Moles of O_2 = molarity x volume

= 0.04 mol/L x 10 L

= 0.4 moles **(01 marks)**

(d)

(i) The law of mass action
States that; the rate of reaction is directly proportional to the concentration of reacting species each raised to the power of their stoichiometric coefficients

(ii) Equilibrium law
States that; if the system has attained equilibrium, the ratio of the Product os products concentrations to the products of reactant concentrations each raised to the power equal to their stoichiometric coefficients is constant.

(iii) Reaction quotient
Is a factor that measures the relative amount of reagents in reactions and it is obtained by the ratio of the concentration of products to that of reactants each raised to the power of its stoichiometric coefficients if the reaction is not attained equilibrium

(iv) Equilibrium concentration
Is the concentrations of reagents that has attained equilibrium

(@ 01 marks = 04 marks)

9. (a) Effects of substituents groups on the reactivity of benzene ring.
The substituent groups which are attached in the benzene ring are categorized into two groups

i. Activators
Activators are the substituents groups which help to increase the reactivity of the benzene ring by releasing electrons either by positive inductive effect or by positive mesomerism making benzene more reactive toward the incoming species. Examples of activators include alkyl groups, hydroxyl group, amine, etc **(2marks)**

ii. Deactivators
Deactivators are the substituent groups which tend to withdraw the electrons away from the benzene ring by either negative inductive effects or negative mesomerism that cause the electron density to be reduced in the benzene ring making benzene to be less reactive hence slower in reaction with incoming g species **(2 marks)**

(b) Benzene undergoes electrophilic substitution reaction whereas akene undergoes electrophilic addition reaction

- because in benzene have delocalized pi-bond electrons which are not easily available for the reaction hence they don’t acts as source of electron instead the reaction has to take place at the weak electrophile site that is hydrogen which is substituted by strong electrophile

- but alkene has localized of fixed pi- bond electrons which acts as source electrons hence it undergoes electrophilic addition reaction. **(2 marks)**

(c) Activators attached to the benzene ring directs the incoming electrophile to Ortho and para positions
Because the activators tend to make orthro and para carbon atom to be reactive by increasing the electron density at these carbon atoms position. **(2marks)**

(d) Write the structure of compound **K and L** **(2marks)**

K = $CH_3C(O)\ CH_3$

L = $CH_3CH_2C\ (O)H$

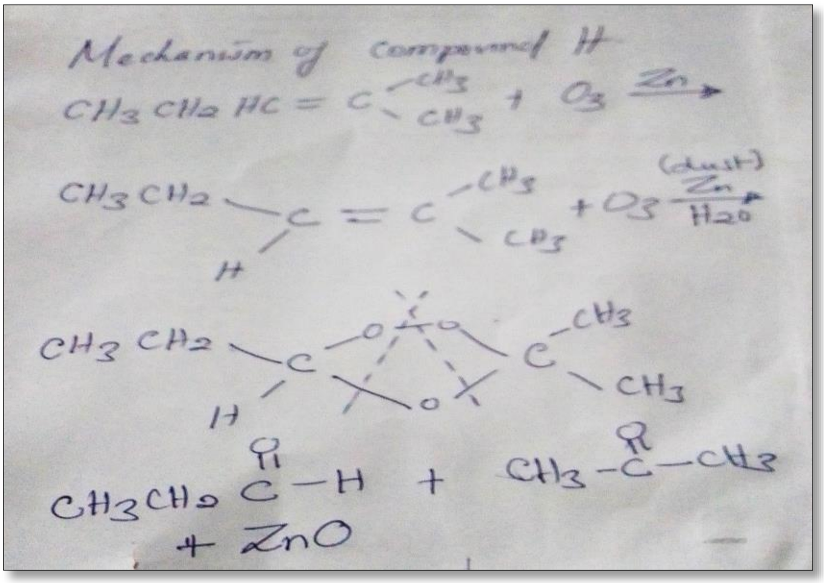
i. Show how to deduce the structure of compound **H**

Compound H = L + K

Compound H = $CH_3 - CH_2 - HC = \boxed{O + O} = C\ (CH_3)_2$ **(1mark)**

Compound H = $CH_3 - CH_2 - HC = C\ (CH_3)_2$ **(1mark)**

ii. Write the mechanism of ozonolysis of compound H in the presence of zinc. (**3marks)**



10. (a)

Molal elevation constant

Is the raise in temperature when one mole of a solute is added into 1 kg of a solvent

Molal depression constant

Is the temperature lowered when one mole of the solute is added into 1 kg of a solvent

Vapour pressure

Is the pressure exerted by the vapour in equilibrium with the liquid at constant temperature

Colligative properties

Are the properties of a solution that depends on the amount of a nonvolatile solute added but does not depend on the nature of the solute

(@ 01mark = 04 marks)

(b) Data given

Mass of solvent (wo) = 22g

Mass of solute (ws) = 0.586g

Molar mass of solute (M) = 128gmol^{-1}

Initial temperature (Tb) = 1.262°C

Temperature of the solution (T) = 1.799°C

ΔTb = T- Tb

= 1.799 – 1.262

= 0.537°C **(00½mark)**

Then

(00½ mark)

For solution containing solute X

Mass of solvent (Wo) = 22g

Mass of solute 0.694g

Boiling point elevation (ΔTb) = 1.963-1.269

= 0.694°C **(00½mark)**

From **(00½mark)**

(c) Data given

Mass of solute (Ws) = 0.6677g

Mass of solvent (Wo) = 35.5g

Freezing point depression (ΔTf) = 0.215°C

Cryoscopic constant (Kf) = 1.85°C/kgmol^{-1}

Normal molecular mass (C_6H_5OH) = 94 gmol^{-1}

From

(00½mark)

(01mark)

From **(00½mark)**

Then;

$2C_6H_5OH \rightleftharpoons (C_6H_5OH)_2$

N = 2 **(00½mark)**

For association

(00½mark)

(d)

Because salts is an electrolyte that dissociates leading into increase in number of particles that will increase the osmotic pressure of the blood

So as to lower the freezing point of water as a result water do not freeze

Because salt dissociates into water as a result it will increase the boiling point of water and longer time will be used to cook

The pressure applied to the solution so as to stop the movement of solvent molecules into the solution side through a semi-permeable membrane

(@00½ mark = 02 marks)