QUESTIONS

Question 1

A salt solution sits in an open beaker. Assuming constant temperature and pressure; would you expect the vapour pressure of the solution to decrease, to increase or to remain the same over time? Explain.

Question 2

Explain why a raw mango shrivels when placed in concentrated salt solution.

Question 3

Explain why wilted flowers revive when placed in fresh water.

Question 4

The depression in freezing point of water observed for the same amount of acetic acid, trichloroacetic acid and trifluoroacetic acid increases in the order given above. Explain briefly.

Question 5

Osmotic pressure and freezing point depression have the same origin. Explain.

Question 6

What are isotonic solutions? Explain.

Question 7

Why 0.1molar HCl shows greater depression in freezing point than 0.1molar acetic acid?

Question 8

Why electrolytes have abnormally high values of colligative properties?

Question 9

Addition of non-volatile solute lowers the freezing point and elevates the boiling point of a solvent. Explain giving reason(s).

Question 10

Explain why a carrot that has become limp because of water loss into the atmosphere becomes firm once again when placed into the water.

Question 11

Equimolar solutions of sucrose and sodium chloride in water are not isotonic. Explain giving reasons.

Question 12

State and derive Raoult's law for lowering of vapour pressure. How is this law used for the determination of molecular mass of a non-volatile solute?

Question 13

(i) Differentiate between osmosis and osmotic pressure.
(ii) Is the osmotic pressure of a solution a colligative property? Explain.

Question 14

Explain why addition of salt or sugar can protect food against bacteria actions and therefore helps as the method of food preservation.

Question 15

Concentration of solution can be expressed in different methods. The choice of the convenient method in different circumstances depends on number of factors. **Molarity** and **molality** are broadly used as among methods of representing concentration with the former being more often used than the latter.

(i) Differentiate **molality** from **molarity**.
(ii) Why molarity is more famous than molality?
(iii) In determination boiling point elevation and freezing point depression molality (**not** molarity) is used while in determination osmotic pressure molarity (**not** molality). Give an explanation to support the choice.

Question 16

Why benzoic acid dissolved in benzene shows a lesser value of osmotic pressure than expected one while when dissolved in water it shows greater value than the expected one?

Question 17

What is the relationship between the Van't Hoff factor for a compound and its lattice energy?

Question 18

Outline the limitations of colligative properties

Question 19

Why the solution must be dilute for colligative properties to be observed?

Question 20

List down two factors to which colligative properties depend.

Question 21

Briefly explain how the magnitude of colligative properties is affected if in the solution the solute undergoes:

(i) Dissociation
(ii) Association

Question 22

What is the role of non-volatile solute in lowering of vapour pressure of solvent?

Question 23

List the following aqueous solution in order of increasing boiling point:

$$0.03\text{m}MgSO_4, 0.03\text{m}CaCl_2, 0.04\text{m sucrose}$$

Explain your selection.

Question 24

Two beakers of equal volume are placed in a room. Beaker A contains pure water and beaker B contains salt water. After a day of evaporation, which has more liquid in it and why?

Question 25

Explain what happens when blood cells are placed in pure water?

Question 26

To get the hard boiled eggs, why common salt is added to water before boiling the eggs?

Question 27

Out of 1 M glucose and 2 M glucose, which one has a higher boiling point and why?

Question 28

What happens when the external pressure applied becomes more than the osmotic pressure of solution?

Question 29

Measurement of osmotic pressure is more widely used for determining molar masses of macromolecules than the elevation in boiling point or depression in freezing point of their solutions. Give two reasons to support this fact.

Question 30

Why does sodium chloride solution freeze at a lower temperature than water?

Question 31

Among the following solutions, which one is hypertonic? Explain.

A: 0.1M aqueous calcium chloride
B: 0.1M aqueous glucose
C: 0.1M aqueous ammonium phosphate
D: 0.1M benzoic acid solution in benzene

Question 32

Why adding salt to the ice makes the ice to melt?

Question 33

Why osmosis does not take place in two isotonic solutions separated by a semi-permeable membrane?

Question 34

The Van't Hoff factor for a concentrated solution of NaCl is much less than 2, while that for a dilute solution is only slightly less than 2. Explain.

Question 35

The addition of lead (II) ions to a solution of magnesium chloride leads to an increase in the vapour pressure of the solution. Explain.

Question 36

Explain how colligative properties are important in making antifreeze?

Question 37

Between $0.1MBaCl_2$ and $0.1MCaCl_2$ which one has larger Van't Hoff's factor? Explain.

Question 38

As a solution freezes, the freezing temperature continues to decrease. Why is this so?

Question 39

Van't Hoff's factor may help us to determine degree of dissociation or association of non-volatile solute in the solution. Briefly explain the relationship between Van't Hoff's factor and concentration of the solution.

Question 40

The Van't Hoff factor for a 0.05molal $FeCl_3$ solution is much smaller than 4, while that for the same concentration of NaCl is only slightly less than 2. Explain.

Question 41

State the following:

(i) Van't Hoff's law of osmotic pressure

(ii) Blagden's law

Question 42

Colligative properties are very useful for experimental determination of molar masses of non-volatile solute.

(i) Mention three colligative properties apart from osmotic pressure.

(ii) State two methods which employ colligative properties in the molar mass determination.
(iii) In the determination of molar mass, is it better to use diluted or concentrated solution? Explain.
(iv) In the experiment of determining molar mass; it is better to employ osmotic pressure measurement than other ways like ebullioscopy and cryoscopy. Give one reason to oppose and two reasons to support this statement.

Question 43

Give a reason for each of the following:

(i) Meat can be classified as fresh (not frozen) even though it is stored at −1 °C. Why wouldn't meat freeze at this temperature?
(ii) One mole of sodium chloride depress the freezing point of 1kg of water almost twice as much as one mole of glycerine?

Question 44

Define the following:

(i) Cryoscopy
(ii) Ebullioscopy

Question 45

What do you understand by the following:

(i) Colligative properties
(ii) Freezing point
(iii) Non-volatile solute
(iv) Boiling point

Question 46

Briefly explain with reason(s) whether the osmotic pressure method would be satisfactory for determining relative molecular mass of ethanoic acid in a concentrated solution of the acid in a suitable solvent.

Question 47

(i) What are colligative properties?

(ii) Mention limitations for colligative properties to be observed

(iii) You take a bottle of a soft drink out of your refrigerator. The contents are liquid and stay liquid even when you shake them. Thirstily, you remove the cap, and the liquid freezes solid! Offer a possible explanation of this observation.

Question 48

(i) What is boiling point of liquid?

(ii) How boiling point is affected by external pressure?

Question 49

Define the following terms:

(i) Colligative properties
(ii) Ebullioscopic constant
(iii) Osmotic pressure

Question 50

(i) Is molarity or molality dependent on temperature? Explain your answer.

(ii) Why is molality and not molarity used in mathematical equations describing the amount of freezing point depression and boiling point elevation?

Question 51

(i) Why is the observed freezing point for electrolyte commonly less than the calculated value?

(ii) Is the discrepancy in (i) above, greater for concentrated or diluted solution? Explain.

Question 52

Define the following two terms: osmotic pressure and reverse osmosis.

Question 53

Briefly explain the following in terms of vapour pressure:

(i) Boiling point of water rise due to addition of table salt.

(ii) Freezing point of a solution is lower than that of a pure solvent.

Question 54

Colligative properties are very useful in determination of molar mass of non-volatile solutes.

(i) What is the non-volatile solute?

(ii) Explain why osmotic pressure is more preferred in the determination of molar mass of substance with large molar mass like protein than freezing point depression or boiling point elevation?

Question 55

Explain what is mostly likely to happen when cucumber is placed in a concentrated salt solution.

Question 56

Does seawater boil at the same temperature as distilled water? If not, which has the higher boiling point? Explain your answer.

Question 57

Compare effect of calcium carbonate and sodium carbonate on boiling point of water.

Question 58

The boiling point of diethyl ether is 34.6℃. Would this compounds be considered non-volatile? Give reason.

Question 59

Boiling point elevation is directly proportional to the molal concentration of the solute. Is it also directly proportional to the molar concentration of the solution? Why or why not?

Question 60

Many people get thirsty after eating foods such as ice cream or potato chips that have a high sugar or salt content, respectively. Suggest an explanation for this phenomenon.

Question 61

Silver chloride is a non-volatile material, but does not dissolve in water. What effect will it have on the vapour pressure of water?

Question 62

If you were stranded on a desert island, why would drinking seawater lead to an increased rate of dehydration, eventually causing you to die of thirst?

Question 63

When two aqueous solutions with identical concentrations are separated by a semipermeable membrane, no net movement of water occurs. What happens when a solute that cannot penetrate the membrane is added to one of the solutions? Why?

Question 64

Rahma is your friend who study advanced chemistry at **Madungu secondary school** located at **Pemba Island**. She was given an assignment on topic of colligative properties. However she is not sure about her response to some of questions. Below are responses, **Rahma** doubted about their accuracy.

(i) Isotonic solutions at given temperature have the same boiling point elevation and freezing point depression.

(ii) Two different solutions with the same effective molality in the solution exhibit the same boiling point elevation.

(iii) Colligative properties do not depend on the nature of solvent.

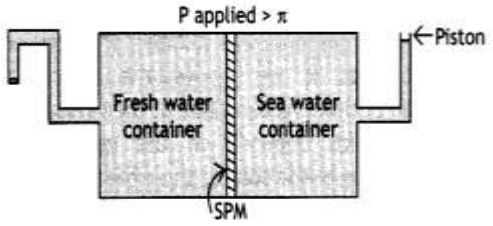
If **Rahma** came to you and seek for your help; then guide your friend by telling her whether each statement is correct or not and provide for her clear explanation to support your guidance.

Question 65

Consider a 4% starch solution and a 10% starch solution separated by a semipermeable membrane, which starch solution will decrease in volume as osmosis occurs? Give reason to support your choice.

Question 66

Given below is the sketch of a plant for carrying out a process.



(i) Name and define the process occurring in the above plant.
(ii) To which container does the net flow of solvent take place?
(iii) What does SPM stands for?
(iv) Name one SPM which can be used in this plant.

(v) Give the main practical use of the plant.

Question 67

Consider a 0.1M starch solution and a 0.2M starch solution separated by a semipermeable membrane, which starch solution will increase in volume as osmosis occurs? Give reason to support your choice.

Question 68

Why the boiling point 0.1m$BaCl_2$ solution is more than 0.1mNaCl solution?

Question 69

Which would have the lower vapour pressure—an aqueous solution that is 0.12 M in glucose or one that is 0.12 M in $CaCl_2$? Why?

Question 70

Magnesium chloride is dissolved in water to make the solution in which its concentration is 0.1M.

(i) What is the theoretical value of Van't Hoff's factor of $MgCl_2$ in aqueous solution?

(ii) Explain why the value mentioned in (i) above cannot be realized in practice.

(iii) Explain what can be done to make the experimental value of Van't Hoff's factor of $MgCl_2(aq)$ to approach the theoretical value.

Question 71

Arrange the following solution in order of increasing in their vapour pressure. Comment on you answer.

A: 0.001M $CO(NH_2)_2$ B: 0.001M AgCl

C: 0.001M$BeCl_2$ D: 0.001M $AlCl_3$

Question 72

Study the table below and answer the question that follows:

Solution	Concentration in mol/L	Freezing point (℃)
Cane sugar $C_{12}H_{22}O_{11}$	0.03	-0.054
Glycerol $C_3H_8O_2$	0.132	-0.200
Potassium bromide KBr	0.084	-0.300

Giving reasons comment on the variation of freezing point with respect to concentration of the solution in the above table.

Question 73

Give one main practical application of colligative properties.

Question 74

Why the solute must be non-volatile for colligative properties to be observed?

Question 75

The vapour pressure of water at 25℃ was observed to be 3167Pa. Explain briefly what will happen to this vapour pressure if 4g of sugar are dissolved into the water at the same temperature.

Question 76

Assuming the price per kilogram is the same:

(i) Which is a better salt to use for deicing wintry roads—NaCl or $MgCl_2$? Why?

(ii) Would magnesium chloride be an effective deicer at a temperature of $-8°C$?

Question 77

With reason, predict whether Van't Hoff factor is less than one, greater than one or equal to one in the following:

CH_3COOH dissolved in water.

CH_3COOH dissolved in benzene.

$CO(NH_2)_2$ dissolved in water.

Question 78

List down four uses of freezing point depression.

Question 79

NaCl is less expensive than either $CaCl_2$ or $MgCl_2$. However in salting of roads in cold-weather climates, $CaCl_2$ and $MgCl_2$ are used most frequently.

(i) What is the main aim of salting the road?
(ii) Why $CaCl_2$ and $MgCl_2$ are more preferred?

Question 80

A solute in a solution behaves exactly like a gas and the osmotic pressure of a dilute solution is equal to the pressure which the solute would exert if it were a gas at the same temperature occupying the same volume.

(i) Which theory is this statement based?
(ii) The theory stated in (i) above is useful in deducing number of laws. State them.

Question 81

Arrange the following aqueous solution in order of increasing freezing point:

$0.01MC_2H_5OH, 0.01MBa_3(PO_4)_2, 0.01MNa_2SO_4, 0.01MKCl,$

$0.01MLi_3PO_4$Provide clear reason(s) for arrangement.

Question 82

Consider the following solutions:

$0.010mNa_3PO_4$ in water
$0.020mCaBr_2$ in water
$0.020mKCl$ in water

$0.020\text{M}HF$ in water

(a) Complete the following table for the above solutions:

Solution	**Van't Hoff factor,i**	**Effective molality of solute,m**
$0.010\text{m}Na_3PO_4$		
$0.020\text{m}CaBr_2$		
$0.020\text{m}KCl$		
$0.020\text{m}HF$		

(b) Which solution(s) would have the same boiling point as $0.040\text{m}C_6H_{12}O_6$ in water?

(c) Which solution(s) would have the lowest freezing point?

(d) Which solution(s) would have highest vapour pressure $30°C$?

(e) Which solution(s) would have nearly the same osmotic pressure as $0.020\text{m}C_6H_{12}O_6$ in water?

Question 83

Colligative properties are very special physical property of the solution. They are very special in different perspective; from their origin to their useful application.

(i) List down three things which make colligative properties special.

(ii) Mention at least four properties of solution which are **not** regarded as colligative properties.

Question 84

Blood cells are isotonic with 0.9% sodium chloride solution. What happens if we place blood cells in a solution containing:

(i) 1.2% sodium chloride solution?
(ii) 0.4% sodium chloride solution?

Question 85

Arrange the following aqueous solutions in order of decreasing freezing points:

0.10m KNO_3
0.10m $BaCl_2$
0.10m $C_2H_4(OH)_2$
0.10m Na_3PO_4

Question 86

List the following solutions in order of increasing melting point:

$0.1\text{m sugar}, 0.1\text{mNaCl}, 0.08\text{m } CaCl_2, 0.04\text{m}Na_2CO_3$

SOLUTIONS

Question 1

Vapour pressure of the solution will **decrease**.

Explanation:

As the time pass over, solvent undergoes evaporation leaving salt particles which are non-volatile. As result concentration of solute in the solution is continuously increasing leading to more lowering in vapour pressure and hence decrease in the vapour pressure of the solution over time.

Question 2

Reason:

Mango loses water by osmosis.

Explanation

Concentrated salt solution is hypertonic with respect to mango. So when mango is placed in the solution, mango loses water to the solution by osmosis and consequently it shrivels.

Question 3

Reason:

Water flows into flowers by osmosis.

Explanation:

Fresh water is hypotonic with respect to the flowers. So when wilted flowers are placed in fresh water, flowers will

absorb water by osmosis and hence they regain their freshness.

Question 4

The given compounds are electrolytes so they tend to ionise in water thereby increasing number of solute particles in the solution and hence more increase in freezing point depression. Their extent of ionisation in the solution is determined by their acidic strengths whereby fluorine being more electronegative exerts stronger negative inductive effect than chlorine making trifluoroacetic acid stronger acid than trichloroacetic acid while acetic acid having no negative inductive effect at all is the weakest acid among the three. Consequently the degree of ionisation and hence freezing point depression will obey the given order.

Question 5

They are both colligative properties which are determined by solute concentration in the solution. Furthermore they both occur (bound) together in the solution; that is the solution cannot have osmotic pressure without having freezing point depression.

Question 6

Are solutions with equal osmotic pressure. Are solutions with the same concentration and therefore the same vapour pressure at given temperature. As an example, 0.1M

aqueous glucose and 0.1M aqueous urea are isotonic solutions at room temperature.

Question 7

HCl is strong acid while acetic acid is weak acid; so the former ionises almost completely in the solution to give greater number of solute particles and hence greater depression in freezing point than the latter which ionises only partially.

Question 8

Electrolytes undergo dissociation in solution making the observed number of particles abnormally high and hence abnormally high values of colligative properties.

Question 9

Non-volatile solute lowers vapour pressure of the solution. The lowering in vapour pressure means that the liquid solution will need higher temperature to raise its vapour pressure so that it equalize to atmospheric pressure and hence its boiling point elevates. Also the lowering in vapour pressure means that the solid phase of the solution will need lower temperature to raise its vapour pressure so that it equalize to the vapour pressure of liquid solution and hence lowering in freezing point.

Question 10

Reason

Water flows into carrot by osmosis.

Explanation

Fresh water is hypotonic with respect to the carrot. So when limped carrot is placed in fresh water, the carrot will absorb water by osmosis and hence it regain its firmness.

Question 11

Sucrose is non-electrolyte while sodium electrolyte is strong electrolyte. So with equimolar of their solutions, sodium chloride will ionise (dissociate) almost completely to give almost twice the sucrose concentration and hence its osmotic pressure will be almost twice too making the NaCl solution hypertonic to sucrose solution and not isotonic.

Question 12

When a non-volatile solute is dissolved in the solvent at given temperature, the lowering of the vapour pressures of the solvent in the solution varies directly proportional to the mole fraction of the solute.

Derivation:

Consider a non-volatile solute is dissolved in a liquid solvent to form very dilute solution:

By Raoult‘s law: $P_{sv} = X_{sv}P^{o}_{sv}$

and $P_{su} = X_{su}P^{o}_{su}$

Where:

$P_{sv}$and P_{su} are partial vapour pressures exerted in solution by solvent and non-volatile solute respectively.

$P^o_{sv\ and} P^o_{su}$ are vapour pressures of pure solvent and pure non-volatile solute respectively.

X_{sv} and X_{su} are mole fractions in the solution for solvent and non-volatile solute respectively.

By combining Raoult's law and Dalton's law of partial pressures: $P_{soln} = X_{sv}P^o_{sv} + X_{su}P^o_{su}$

But for non-volatile solute, $P^o_{su} = 0$

Then $P_{soln} = X_{sv}P^o_{sv}$

But $X_{sv} = 1 - X_{su}$ $\quad (X_{sv} + X_{su} = 1)$

The $P_{soln} = (1 - X_{su})P^o_{sv}$ or $P_{soln} = P^o_{sv} - X_{su}P^o_{sv}$ Or $X_{su}P^o_{sv} = P^o_{sv} - P_{soln}$

But $P^o_{sv} - P_{soln}$ = Lowering in the vapour pressure of the solvent, ΔP

It follows that: $\Delta P = X_{su}P^o_{sv}$

But P^o_{sv} is constant at given temperature

Hence $\Delta P \propto X_{su}$ (Raoult's law for lowering of vapour pressure)

Molecular mass determination:

From Raoult's law of lowering in vapour pressure; $\Delta P = X_{su}P^o_{sv}$

From which; $X_{su} = \frac{\Delta P}{P^o_{sv}}$, but $X_{su} = \frac{n_{su}}{n_{su}+n_{sv}}$

For very dilute solution: $n_{sv} >> n_{su}$

Such that: $n_{sv} + n_{su} \approx n_{sv}$

And it becomes: $X_{su} = \frac{n_{su}}{n_{sv}}$

Thus from: $X_{su} = \frac{\Delta P}{P^0_{sv}}$

It follows that: $\frac{n_{su}}{n_{sv}} = \frac{\Delta P}{P^0_{sv}}$

But $n_{su} = \frac{m_{su}}{M_{su}}$ and $n_{sv} = \frac{m_{sv}}{M_{sv}}$

Then $\frac{n_{su}}{n_{sv}} = \frac{m_{su}M_{sv}}{m_{sv} \times M_{su}} = \frac{\Delta P}{P^0_{sv}}$

Hence $M_{su} = \frac{m_{su} \times M_{sv} \times P^0_{sv}}{m_{sv} \times \Delta P}$

Therefore with measured mass of solvent and non-volatile solute, vapour pressure of solvent and solution (which gives lowering in vapour pressure), molecular mass of non-volatile solute can be determined.

Question 13

(i) Osmosis is the spontaneous flow of solvent through semi-permeable membrane from a solution of low solute concentration to one of higher solute concentration whereas osmotic pressure is the external pressure required to be applied in the solution side to prevent osmosis in the solvent-solution system.

(ii) Yes.

Explanation:

From experiment, it can be shown that:

$\pi V = nRT$ or $\pi = CRT$ where $C = \frac{n}{V}$

Where π is the osmotic pressure exerted by n moles of solute dissolved in the solution of volume, V at absolute temperature, T.

If T is constant, RT gives another constant and the above equation becomes;

$$\pi = C \times \text{constant or } \pi \propto C$$

Since the osmotic pressure varies directly proportional to molar concentration, C; it is colligative property.

Question 14

The salt or sugar increases the solute concentration to a level above that present in living organisms making the food hypertonic with respect to bacteria. So any bacterial cell (which is surrounded by semi – permeable membrane) that wanders into such food will have its water drawn out by osmosis and eventually will die of dehydration.

Question 15

(i) Molarity measures concentration of solute in the solution as the ratio of number of moles of the solute to the volume of the solution whereas molality is measured as the ratio of number of moles of the solute to the mass of solvent. Thus the unit of molarity is mol/L while that of molality is mol/kg.

(ii) It is easier to measure volume and hence molarity with greater accuracy than to measure mass and hence molality.

(iii) Measuring freezing point depression and boiling point elevation involve varying temperature of the solution; so because volume and thus molarity changes as temperature changes molarity does not suit in their measurements unlike mass and thus molality whose value is not affected by temperature change.

However since measurements of osmotic pressure are done at fixed temperature (usually room temperature) the easier and more accurate method which is molarity is preferred to molality

Question 16

In benzene, benzoic acid undergoes association to form dimer, thus decreasing number of solute particles in the solution leading to smaller value of osmotic pressure in contrast to water in which the acid undergoes dissociation giving greater number of solute particles in the solution.

Question 17

High lattice energy for a compound means more difficult for the compound to dissolve in the solution to give free ions. More difficult to undergo dissociation to give free ions means fewer solute particles in the solution which in turn means smaller Van't Hoff's factor. Hence compounds with high lattice energy have small Van't Hoff's factor

while compounds with low lattice energy have large Van't Hoff's factor.

Question 18

Limitations of colligative properties are:

(i) Non-volatile solute

The liquid solution must contain non-volatile solute for colligative properties to be witnessed. Colligative properties are not observed when the solute is volatile.

(ii) Dilute solution

Colligative properties are not observed in concentrated solution. The solution must be dilute for colligative properties to be observed.

Question 19

To make the solution ideal so that it can obey Raoult's law.

Question 20

1. Amount of solute
2. Nature of solvent

Question 21

(i) Dissociation increases number of solute particles in the solution and therefore makes the observed colligative property to be greater than one could expect if would be no dissociation.

(ii) Association decreases number of solute particles in the solution and therefore makes the observed colligative

property to be smaller than one could expect if would be no association.

Question 22

When a non-volatile solute is added to a solvent, the vapour pressure is lowered due to the following reasons:

- Percentage surface area occupied by the solvent decreases (this because some surface of the solvent is covered by the solute and therefore reducing the chance of the solvent to evaporate).
- Mole fraction(concentration)of the solvent is decreased

Question 23

$0.04\text{m sucrose} < 0.03\text{m } MgSO_4 < 0.03\text{m} CaCl_2$

Lowest boiling point highest boiling point

Explanation

- Greater molality of the solute in the solution, greater boiling point elevation and therefore higher boiling point to the solution

  Sucrose being non-electrolyte (covalent compound) does not undergo dissociation thus 0.04m sucrose is equivalent to the 0.04mol of the solute in 1kg of the solvent.

  $MgSO_4$ being ionic compound,undergo ionisation (dissociation) according the following equation:

$$MgSO_4 \longrightarrow Mg^{2+} + SO_4^{2-}$$

$0.03\text{m} \quad 0.03\text{m} \quad 0.03\text{m}$

So assuming complete ionisation,0.03m $MgSO_4$ is equivalent to the 0.06mol of solute in 1kg $(0.03\text{m} + 0.03\text{m} = 0.06\text{m})$ of the solvent

$CaCl_2$ being ionic, undergo ionisation according to the following question

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$$

$0.03\text{m} \quad 0.03\text{m} \quad 2 \times 0.03\text{m} = 0.06\text{m}$

Assuming complete ionisation 0.03m $CaCl_2$ is equivalent to 0.09mol $(0.03\text{mol} + 0.06\text{mol} = 0.09\text{mol})$ of solutes in 1kg of the solvent

Question 24

Beaker B

Reason

Beaker B contain the solution(salt water),this there is lowering in vapour pressure due to presence of salt(non-volatile solute) making the vapour pressure in beaker B lower than that of beaker A which contain pure water (solvent). Lower vapour pressure of liquid in beaker B means less evaporation.

Question 25

In blood cells−pure water system, pure water being pure solvent with zero concentration of solute has lower osmotic pressure. Since cell membrane is semi-permeable membrane, osmosis will take place by water molecules

moving into blood cell (which has higher osmotic pressure) through the cell membrane. So blood cells swell and may even burst.

Question 26

Due to addition of common salt (non-volatile solute), the boiling point of the salt containing water are elevated and the egg become hard at high temperature (above normal boiling point of pure water).

Question 27

The elevation in boiling point is a colligative property and depends upon the number of moles of solute added. Higher the concentration of solute added, higher will be the elevation in boiling point. Thus, 2M glucose solution has higher boiling point than 1 M glucose solution.

Question 28

When the external pressure applied becomes more than the osmotic pressure of the solution, then the solvent molecules from the solution pass through the semipermeable membrane to the solvent side. This process is called reverse osmosis.

Question 29

The osmotic pressure method has the advantage over elevation in boiling point or depression in freezing point for determining molar masses of macromolecules because:

1. Osmotic pressure is measured at the room temperature and the molarity of solution is used instead of molality.
2. Compared to other colligative properties, its magnitude is large and therefore measurable even for very dilute solutions.

Question 30

When a non-volatile solute like NaCl is dissolved in a solvent, the vapour pressure decreases. As a result, the solvent freezes at a lower temperature.

Question 31

Hypertonic solution is C: 0.1M aqueous ammonium phosphate.

Explanation:

With formula $(NH_4)_3PO_4$, ammonium phosphate undergoes dissociation in aqueous solution to give four ions per molecule and therefore giving greatest concentration of solute in the solution and hence highest osmotic pressure.

Question 32

Adding the salt which is non-volatile causes freezing point depression and therefore makes melting point of the resulting solution to be below ice temperature and hence the ice will melt upon addition of the salt.

Question 33

Isotonic solutions have the same osmotic pressure which means equal concentration and hence osmosis will not occur.

Question 34

The Van't Hoff's factor is large when the degree of dissociation (or ionisation) is large too. When the solution is more concentrated, the degree of dissociation is lowered and therefore the Van't Hoff's factor becomes smaller.

Question 35

Whether is through formation of precipitate of lead (II) chloride whereby two moles of chloride ions form one mole of lead (II) chloride precipitate or through formation of complex whereby four moles of chloride ions form one mole of complex ($[PbCl_4]^{2-}$), the introduction of lead (II) ions decreases number of solute particles which means less lowering in vapour pressure and hence increase in vapour pressure.

Question 36

In making anti-freeze ethylene glycol is added to water and therefore doing both decreasing freezing point and raising boiling point of water. The resulted freezing point depression and boiling point elevation means that the radiator can work in extremely low temperature without freezing and extremely high temperature without boil overs and hence operating range of cooling system has been increased by colligative properties.

Question 37

$0.1\text{M}BaCl_2$

Explanation:

Van't Hoff's factor is high when degree of ionisation (dissociation) is high. $BaCl_2$ being more ionic as result of its lower degree of polarization resulted from weaker polarizing power of larger sized Ba^{2+} than Ca^{2+} in $CaCl_2$ has greater degree of ionisation in aqueous solution.

Question 38

As a solution freezes, the solvent molecules are removed from the solution which causes an increase in the concentration. This causes further freezing temperature depression.

Question 39

For dissociation the Van't Hoff's factor is greater than one and its value is large when the degree of dissociation (or ionisation) is large too. When the solution is more concentrated, the degree of dissociation is lowered and therefore the Van't Hoff's factor becomes smaller. In some cases high concentration may lead to association between solute particles making the factor much smaller where it becomes less than one.

Question 40

The Van't Hoff's factor approaches the ideal value when the salt undergoes complete ionisation. $FeCl_3$ having

higher degree of polarisation as result of greater polarising power of smaller sized and higher changed Fe^{3+} than Na^{+}in NaCl, is more covalent in character and hence it has lower degree of ionisation than NaCl.

Question 41

(i) A solute in a solution behaves exactly like a gas and the osmotic pressure of a dilute solution is equal to the pressure which the solute would exert if it were a gas at the same temperature occupying the same volume.

(ii) The depression of the freezing point of dilute solutions is proportional to the amount of the dissolved substance.

Question 42

(i)

1. Lowering in vapour pressure
2. Freezing point depression
3. Boiling point elevation

(ii)

1. Beckmann's method
2. Landsberger's method

(iii) Diluted solution

Explanation

Better result of determination of molar mass by colligative properties are obtained when the solution is almost ideal and the solution containing non-volatile solution becomes almost ideal when it is dilute.

(iv) **Reason to oppose:**

It is difficult to measure osmotic pressure as it requires a more advanced apparatus and hence the experiment cannot be carried out as an ordinary laboratory process.

Reason to support:

1. The osmotic pressure measurements are taken around room temperature.
2. The molarity of the solution is used in measuring osmotic pressure instead of molality. It is easier to measure molarity than molality.
3. It is useful for determination of molar mass of biomolecules (polymers) as they are generally not stable at higher temperatures.
4. It is useful for determination of molar mass of substances with large molar mass as the osmotic pressure is measurable for those substances unlike boiling point elevation and freezing point depression.

Question 43

(a) Non-volatile ions and compounds present in the water in the beef lower the freezing point of the beef below −1 °C.

(b) Unlike glycerine which is non-electrolyte (covalent), NaCl being strong ionic (electrolyte) ionises almost completely to give twice as much as its number of moles**.**

Question 44

(i) Is the process of measuring freezing point depression so as determine molar mass of non – volatile solute.

Question 45

(i) Are properties of solution which depend on the relative amount of solute and solvent but not on the nature of the solute. Are properties of solution which are boiling point elevation, boiling point elevation, lowering in vapour pressure and osmotic pressure.

(ii) Is the temperature at which vapour pressure exerted by liquid phase of a substance is equal to that exerted by its solid phase. Is the temperature at which liquid phase and solid phase of the substance co-exist at equilibrium.

(iii) Is the component of the solution which does not produce vapour at the boiling point of solution. Non-volatile solutes are substances with low vapour pressure and high boiling point.

(iv) Is the temperature at which vapour pressure of a substance is equal to atmospheric pressure (external pressure). Is the temperature at which liquid phase and gas phase of the substance are at equilibrium.

Question 46

Not satisfactory

Explanation:

Osmotic pressure as one of colligative properties is only applicable when the solution is ideal which demands the solution to be dilute and not concentrated.

Question 47

(i) Colligative properties are properties of solution which depend on the relative amount of solute and solvent and not on the nature of the solute.

These are: lowering of vapour pressure, boiling point elevation, freezing point depression and osmotic pressure.

(ii) Colligative properties are not observed when:

1. The solute is volatile
2. The solution is concentrated (is not very dilute)

(iii) If the soft drink is cooled to temperature that is below the freezing point of pure water, then the dissolved CO_2 lowered the freezing point of the soft drink so that it was still liquid.

But when the bottle is opened, the dissolved CO_2 escape from the solution, decreasing concentration of dissolved solute (gas) and thus raising the freezing point to the temperature above the temperature of solution and hence the solution (soft drink) freeze.

Question 48

(i) Boiling point of a liquid is the temperature at which vapour pressure of the liquid is equal to the atmospheric (external) pressure.

(ii) Increase in external pressure increases boiling point and vice versa.

Question 49

(i) Are properties of the solution which depend on relative amount of solute and solvent and not on the nature of the solute.

(ii) Is the boiling point elevation of the solvent in the solution which is obtained when one mole of non-volatile solute is dissolved in 1 kg of solvent.

(iii) Is the pressure required to be applied to the side of higher solute concentration so as to prevent movement of solvent molecules by osmosis.

Question 50

(i) Molarity

Explanation:

Molarity depends on the volume which is temperature dependent unlike molality which depends on mass and the mass is not affected by temperature.

(ii) Measurement of freezing point depression or boiling point elevation involves changing the temperature of the solution, the action which would change the molarity of the solution. Since molality is temperature independent, it becomes more appropriate to be used in their respective mathematical equations than molarity.

Question 51

(i) Due to **dissociation** of the electrolyte, the observed number of solute particles becomes larger than the expected one leading to the greater freezing point

depression and hence the observed freezing point becomes lower.

(ii) Diluted solution.

Explanation:

In accordance to Ostwald's dilution law, the degree of dissociation (ionisation) is greater in the more diluted solution and therefore the discrepancy becomes greater. Furthermore ion interaction and hence ion pairing is less in the diluted solution.

Question 52

(i) Osmotic pressure is the pressure required to be applied to the side of higher solute concentration so as to prevent movement of solvent molecules by osmosis.

(ii) Reverse osmosis is the non-spontaneous flow of solvent through semi-permeable membrane from a solution of higher solute concentration to one of lower solute concentration.

Question 53

(i) The addition of table salt which is non-volatile solute decreases the vapour pressure of water and hence

boiling point of water is raised.

(ii) The non-volatile solute decreases the vapour pressure of the solvent, making the solid phase to need lower temperature for its vapour pressure to be equal to the

vapour pressure of liquid phase and hence the freezing point is lowered.

Question 54

(i) Is the solution which does not produce vapour at the boiling point of the solution. It is the solute with low vapour pressure and high boiling point; for example, table salt.

(ii) Solute with large molar mass like protein, exerts very small colligative properties. While very small osmotic pressure is measurable, very small boiling point elevation and freezing point depression are not measurable and hence the osmotic becomes more reliable for the determination. Furthermore these large molecules are thermally unstable so they would decompose if the boiling point elevation is used unlike osmotic pressure which is measured at room temperature.

Question 55

Cucumber will lose water by osmosis and eventually will shrivel.

Explanation:

In the concentrated salt solution there is higher solute concentration than that present inside the cucumber. Thus the salt is hypertonic with respect to cucumber and therefore water will flow from the cucumber to the solution by osmosis and consequently it will shrivel.

Question 56

Seawater and distilled water are **not** boiling at the same temperature.

Explanation:

Sea water contain dissolved salts like sodium chloride and magnesium chloride which are non-volatile. These salts cause boiling point elevation making the seawater to boil at higher temperature than distilled water which is pure water.

Question 57

Calcium carbonate being insoluble in water does not interact with water molecules so its effect on boiling point of water is negligible while sodium carbonate being water soluble interacts with water and therefore elevating boiling point of water.

Question 58

No.

Reason:

It boils at a much lower boiling point than water (For substance to be regarded as non-volatile, its boiling point must be above that of water, 100℃).

Question 59

Not directly proportional.

Reason:

Molarity is temperature dependent. So as the temperature changes during the boiling process, molarity will be continuously changing and hence the change of boiling point with respect to molarity will not be linear.

Question 60

Foods with high sugar content have higher osmotic pressure than most of fluids in the body (are hypertonic with respect to body fluids). So eating them makes water to be drawn from cells by osmosis and hence thirsty feeling to the people.

Question 61

Negligible effect, because it does not dissolve in water and therefore cannot interact with water molecules and hence no lowering in vapour pressure of water will be observed.

Question 62

Seawater contains dissolved salts. So it has higher solute concentration and therefore higher osmotic pressure than most of fluids in the body (are hypertonic with respect to body fluids). So drinking seawater will make water to be drawn from cells by osmosis and hence the person will die due to dehydration.

Question 63

Water molecules will move toward the solution where the solute has been added from another solution (with less solute).

Reason:

The solution with more added solute has more solute concentration and therefore it becomes hypertonic. So to equalize concentration in the two solutions water molecules have to move by osmosis toward it.

Question 64

(i) Not correct.

Explanation:

Isotonic solutions have equal molarity at given temperature. Solutions with equal molarity have different molality and hence different boiling point elevation and freezing point depression. Even if molarity and molality would be almost equal (for dilute solutions with water as solvent), still boiling point elevation and boiling point elevation will be different because K_b and K_f values are different for different solvents.

(ii) Not correct

Explanation:

Boiling point elevation does not only depend on the molality of the solute in the solution but also on the nature of solvent which determine K_b value. So even if the molality is the same, boiling point elevation will be different to difference in the K_b values of solvents.

(iii) Not correct

Explanation:

Colligative properties do not depend on the nature of the solute (not solvent). Colligative properties like boiling point elevation and freezing point depression depend on nature of solvents which determines K_b and K_f values. Also lowering in vapour depend on the nature of solvent which determine vapour pressure of pure solvent. Only osmotic pressure does not depend on the nature of solvent.

Question 65

4% starch solution

Reason:

4% starch solution having smaller solute concentration it is hypotonic solution compared to 6% starch solution and thus during osmosis solvent molecules will move from 4% starch solution to 6% starch solution. Consequently the volume of 4% starch solution will decrease as osmosis occurs.

Question 66

(i) **Name:** reverse osmosis.

Definition: Is the forced flow of solvent through semi-permeable membrane from the solution side to the solvent side by applying external pressure which is greater than osmotic pressure to the solution side.

(ii) To fresh water container.
(iii) Semi-permeable membrane.
(iv) Film of cellulose acetate

(v) **Desalination of water** in the purification of drinking water process (in potable water production).

Question 67

0.2M starch solution

Reason:

0.2M starch solution having larger solute concentration, it is hypertonic solution compared to 0.1M starch solution and thus during osmosis solvent molecules will move from 0.1M starch solution to 0.2M starch solution. Consequently the volume of 0.2M starch solution will increase as osmosis occurs.

Question 68

In the solution, $BaCl_2$ ionises to give three ions per formula unit while NaCl gives two ions per formula unit. As result, 0.1m$BaCl_2$ has higher solute concentration leading to larger boiling point elevation and hence higher boiling point of the solution.

Question 69

0.12M in $CaCl_2$

Reason:

$CaCl_2$ being an electrolyte dissociates in the solution to give greater number of solute particles than the non-electrolyte, sucrose which does not dissociate in the solution. So 0.12M$CaCl_2$ has greater number of solute

particles in the solution leading to more lowering in vapour pressure and hence lower vapour pressure of the solution.

Question 70

(i) Theoretical value of Van't Hoff's factor is total number of ions formed per formula unit under assumption that the compound is completely dissociated in the solution. Hence the theoretical value of Van't Hoff's factor is 3.

(ii) Like any other ionic compound, $MgCl_2$ possess some degree of polarization and therefore some covalent characters with tendency of existing as molecule. So even after dissociation, **ion pairing** between some Mg^{2+} and Cl^- will occur leading to the formation of undissociated $MgCl_2$ and thus the number of solute particles in the solution is decreased. Hence the practical value of Van't Hoff's factor is less than 3.

(iii) By diluting the solution to infinite whereby the compound becomes almost completely dissociated and there so much water that hinder interaction between ions (which are very far apart due to dominance of water amount in the solution) and hence ion pairing becomes almost impossible.

Question 71

$$D < C < B < A \xrightarrow{\text{Increase in vapour pressure}}$$

Comment:

Vapour pressures of given solution are lower than that of pure water and the lowering varies directly proportional to the number of particle (concentration) of solute formed after ionisation. The number decrease in order of D, C, B and finally A which does not ionise at all and hence the vapour pressures of solution follow the reverse order.

Question 72

Comment:

Freezing points of given solution decrease from cane sugar, glycerol to potassium bromide, the bromide having lowest freezing point.

Reasons:

Freezing point depressions of given solution increase with an increase in concentration (number of particles) of solute.

- KBr being ionic (strong electrolyte) dissociates (ionises) in the solution according to the equation: $KBr \rightarrow K^+ + Br^-$ thus making concentration of solute (number of particles of solute) almost twice of given concentration. Hence it depresses most the freezing point of water.
- Glycerol and cane sugar being covalent do not dissociate at all in the solution, thus the more concentrated glycerol solution will depress more the freezing point of water.

Question 73

Determination of molar mass of **non-volatile** substances.

Question 74

To make its (non-volatile solute) partial vapour pressure in the solution to be zero.

Question 75

Sugar being non-volatile will lead to lowering of the vapour pressure of water in the solution as the solute reduce the chance of water vapour to escape into the air and it is also lowers the concentration of water.

Question 76

(i) $MgCl_2$ is better option.

Reason:

$MgCl_2$ is more effective because it gives greater number of ions per formula unit ($MgCl_2$ gives 3 ions while NaCl gives 2 ions) and therefore it exhibits greater freezing point depression per given amount.

Question 77

(i) Van't Hoff's factor is greater than 1.

Reason:

CH_3COOH being an electrolyte undergoes dissociation in water.

(i) Van't Hoff's factor is greater than 1

Reason:

In a solvent which has no hydrogen bonds, CH_3COOH undergoes association (dimerization) to form dimer.

(ii) Van't Hoff's factor is equal to 1.

Reason:

$CO(NH_2)_2$ being non-electrolyte undergoes neither dissociation nor association in water.

Question 78

1. In determining molar mass of non-volatile solute.
2. In estimating degree of dissociation of solute in a solvent.
3. In making anti-freeze (mixture of ethylene glycol and water) to prevent freezing of radiator in automobiles.
4. In salting roads so as to prevent formation of ice over the road in cold regions.

Question 79

(i) Salt is applied in icy road (during winter climate) to lower freezing point which in turn means melting point is lowered below ice temperature and hence the ice will melt more quickly, making driving safer.

(ii) $CaCl_2$ and $MgCl_2$ dissociate to give greater number of solute particles (three ions) than NaCl which dissociates into two ions and hence they cause greater melting/freezing point depression making them more effective.

Question 80

(i) Van't Hoff theory of dilute solutions

(ii)

First law:

For dilute solution of a given solute, at constant temperature, the osmotic pressure of the solution is directly proportional to its mass concentration.

Second law:

The osmotic pressure of given concentration of solution is directly proportional to its absolute temperature.

Third law:

Osmotic pressure and temperature being the same, equal volumes of solution contains equal number of moles (or molecules) of the solute.

Question 81

$0.01\text{M}Ba_3(PO_4)_2 < 0.01\text{M}Li_3PO_4 < 0.01\text{M}Na_2SO_4 < 0.01\text{M}KCl < 0.01\text{M}C_2H_5OH$

Reason:

Freezing points of given solutions are lower than that of pure water and the depression varies directly proportional to the number of particle (concentration) of solute formed after ionisation. The number decreases in order of $Ba_3(PO_4)_2$, Li_3PO_4, Na_2SO_4, KCl and finally C_2H_5OH which does not ionise at all and hence the freezing points of solutions follow the reverse order.

Question 82

(a)

Solution	**Van't Hoff factor,i**	**Effective molality of solute, m**

$0.010mNa_3PO_4$	4	0.04m
$0.020mCaBr_2$	3	0.06m
0.020mKCl	2	0.04m
0.020mHF	$1 < i < 2$ or slightly greater than 1	$0.02m < m < 0.04m$ or slightly greater than 0.02m.

(b) $0.010mNa_3PO_4$ and $0.020mKCl$ (Both have effective molality of 0.04m).

(c) $0.020mCaBr_2$ (It has largest effective molality and therefore largest freezing point depression).

(d) 0.020mHF (It has smallest effective molality and therefore smallest lowering in vapour pressure).

(e) 0.020mHF (It has effective molality which is closer to 0.02m).

Question 83

(i)

1. Colligative properties depend on concentration of solute in the solution and not on the nature of solute.
2. Colligative properties are tied together in a manner that changing concentration of solute in the solution changes all colligative properties at the same time.
3. Colligative properties are useful in determination of molar mass of non-volatile substances.

(ii) Non-colligative properties include the following:

1. Viscosity

2. Density
3. Surface tension
4. Solubility
5. Colour

Question 84

(i) 1.2% sodium chloride solution is hypertonic with respect to 0.9% sodium chloride solution or blood cells. So when red blood cells are placed in this solution, water flows out of the cell and they shrink due to loss of water by osmosis.

(ii) 0.4% sodium chloride solution is hypotonic with respect to 0.9% sodium chloride solution or blood cells. So when red blood cells are placed in this solution, water flows into the cells through osmosis and they swell.

Question 85

0.10m $C_2H_4(OH)_2$ >0.10m KNO_3 >0.10m $BaCl_2$>0.10m Na_3PO_4

$\longrightarrow$ Decrease in freezing point

Question 86

$0.08\text{m } CaCl_2 < 0.1\text{m} NaCl < 0.04\text{m} Na_2CO_3$
$< 0.1\text{m}$ sugar