Colligative Properties

Item 1

A solvent recovery plant in Mbale Industrial Park processes large volumes of carbon disulphide (CS_2) used to dissolve elemental sulphur during the formulation of rubber vulcanising agents and agricultural fungicides. Recent batches have shown inconsistent solubility and product performance, prompting the quality control laboratory to investigate whether sulphur exists as simple S atoms or as **associated molecules** in CS_2 solution.
To resolve this, technicians dissolved different masses of pure sulphur in a fixed 80 g of carbon disulphide and measured the freezing point of each solution. The results are summarised below. The plant's freezing-point constant for carbon disulphide is known to be 3.83 K kg mol^{-1}. Management is particularly concerned about the reliability of such **colligative-property** measurements for determining molar mass and wants a full scientific evaluation, including any **limitations of the method**, before deciding on process adjustments or alternative solvents.

Mass of sulphur, m(g)	4	8	12	16	20
Freezing temperature, t (°C)	-112.2	-113.0	-113.7	-114.5	-115.2

The production manager has sought for help from your school. The head of Chemistry department has selectee your A-Level Chemistry class stream to review the laboratory data and advise the technical team ahead of the next process-review meeting.

Task

Prepare a technical educational report for the quality control and production team using your knowledge as a Chemistry student.

Item 2

A Ugandan plastics manufacturing company in Kampala industrial area produces high-grade poly(phenylethene) (polystyrene) for food packaging and insulation panels. A recent supplier batch has shown inconsistent mechanical strength and melting behaviour in final products, which the quality-control laboratory believes may result from variation in the average molecular mass of the polymer chains.
To investigate, technicians prepared several dilute solutions of the polymer in dioxane and measured the osmotic pressure of each at exactly 25 °C. The results are given below.
Management now requires a complete scientific evaluation of the data, including an overview of the colligative properties involved, a clear explanation of why the osmotic-pressure method was selected over alternatives such as cryoscopy, the calculated molecular mass and degree of polymerisation, and any environmental-management concerns associated with polystyrene as a widely used synthetic polymer.

Concentration, C (g dm^{-3})	2.5	5.5	7.0	10.5	13.0	16.5
Osmotic pressure, $\pi \times 10^{-3}$ (atm)	0.294	0.647	0.823	1.235	1.539	1.940

The production manager has invited you as the leader of your A-Level Chemistry study group to analyse the laboratory findings and submit recommendations ahead of the next batch-approval meeting.

Task:

Prepare a brief write up of the technical report you would present at the workshop with the quality-control and production team of the company.

Item 3

A pharmaceutical formulation company in Gulu is in the middle of a product-development crisis. They are scaling up production of a new oral suspension drug that uses ethoxyethane as the extraction and purification solvent. During pilot trials, the solvent recovery step has become unreliable: boiling points of the process solutions are consistently higher than expected, leading to incomplete distillation, excessive energy consumption, product degradation, and costly production delays.

To diagnose the problem, the quality-control laboratory prepared solutions of benzoic acid (a non-volatile solute) in a fixed 150 g of ethoxyethane and measured the boiling points of each at exactly 1 atmosphere pressure. Management now urgently needs a full scientific analysis of these data, including an explanation of how a non-volatile solute affects the boiling point of a volatile solvent at constant external pressure, the limitations of the method they are using for such determinations, and a calculation of the expected boiling point for a trial solution containing 16 g of glucose dissolved in 85 g of ethoxyethane. This information will decide whether to continue with ethoxyethane or switch solvents before the next scale-up run. Below is the data from their trial runs:

Mass of benzoic acid, m (g)	5	10	15	20	25
Boiling temperature, t (°C)	35.09	35.68	36.27	36.86	37.45

The production manager of the company has invited help from your A-Level Chemistry class that is on a study tour to the company to review the laboratory findings and submit recommendations ahead of the emergency technical meeting tomorrow.

Task

Prepare a technical report for the quality-control and production team using your knowledge of solutions.