Molality in Chemistry Questions with Solutions

Q1. Select the correct relation between molarity and molality.
[m = molecular weight of solute, d = density g/mL]

a) $M\left(\frac{m}{100}+\frac{1}{M'}\right)=d$

b) $M'=\left(\frac{1000M}{1000d-Mm}\right)$

c) Both (a) and (b)

d) None of these

Correct Answer. (c) Both (a) and (b)

Q2. The density of 1 M solution of HCl is 1.0585 g/mL. The molality of the solution is:

a) 1.0585
b) 1
c) 0.10
d) 0.0585

Correct Answer. (b) 1

Explanation: Molality, $M'=\left(\frac{1000M}{1000d-Mm}\right)$

$$M'=\left(\frac{1000\times 1}{1000\times 1.0585-58.5\times 1}\right)=1\frac{mol}{kg}$$

Q3. The mole fraction of a solute in an aqueous solution is 0.2. The molality of the solution will be:

a) 13.88
b) 1.388
c) 0.138
d) 0.0138

Correct Answer. (a) 13.88
Explanation: Given X_B = 0.2, X_A = 0.8

Molality, $$m = \frac{X_B \times 1000}{X_A \times M_A} = \frac{0.2 \times 1000}{0.8 \times 18} = 13.88m$$

Q4. measure the molality of 34.5g of sugar dissolved in 215g of water.

a) 0.559 m
b) 0.613 m
c) 0.603 m
d) 0.554 m

Correct Answer. (d) 0.554 m

Q5. Which of the following is the correct formula for molality?

a) Molality = kilograms of solute ÷ litres of solvent
b) Molality = moles of solute ÷ kilograms of solvent
c) Molality = kilograms of solute ÷ kilograms of solution
d) Molality = moles of solute ÷ moles of solution

Correct Answer. (b) Molality = moles of solute ÷ kilograms of solvent

Q6. Calculate the molality of 25.0 grams of KBr dissolved in 750.0 mL of pure water.

Answer.
25.0 g/119.0 g/mol = 0.210 mol
0.210 mol/0.750 kg = 0.280 m

Q7. State true or False. Molality is temperature-dependent.

Answer. False

Q8. Is molality affected by dilution?

Answer. Since molarity and normality are volume dependent, they change with dilution, whereas molality does not.

Q9. Is molarity greater than molality?
Answer. The solution of molality is always greater than molarity. This is because molarity is calculated as mol per unit L (volume of solution), whereas molality is calculated as moles per unit Kg (i.e. mass of solvent). So, in any case, the mass of the solvent is less than the volume of the solution, and thus the molality is greater.

Q10. How can you convert from molarity to molality?

Answer. If you know the density of the solution, you can convert molarity to molality. Calculate the moles of chemical in 1 litre (L) of solution. Because molarity is defined as the number of moles of chemical per litre, this value will simply equal the molarity of the solution.

Q11. How do molality and molarity differ?

Answer. Both molarity and molality are concentration units.
Molarity
The total number of moles of solute per litre of solution is defined as molarity for a given solution. The molarity of a solution is determined by several physical factors, including pressure, temperature, and mass.

$$Molarity = \frac{Number of moles of solute}{Volume of the solution in L}$$

Molality
The term molality is also used to describe the concentration of a solution. Molality (m) is defined as the number of moles of solute in one kilogram of solvent. Molality is expressed in the SI unit as moles per kilogram (mol/kg).

$$Molality = \frac{Number of moles of solute}{Weight of solvent in kg}$$

Q12. A solution of H_2SO_4 with a molal concentration of 8.010 m has a density of 1.354 g/mL. What is the molar concentration of this solution?

Answer.
8.010 m = 8.010 mol / 1 kg of solvent
(8.010 mol) × (98.0768 g/mol) = 785.6 g of solute
785.6 g + 1000 g = 1785.6 g total for solute and solvent in the 8.010 m solution.
1785.6 g / 1.354 g/mL = 1318.76 mL
8.01 moles / 1.31876 L = 6.0739 M = 6.074 M.

Q13. What is the molality of a 3.75 M H_2SO_4 solution with a density of 1.230 g/mL?

Answer.

Mass of 1.00 L of solution:
(1000 mL) × (1.230 g/mL) = 1230 g
Mass of 3.75 mol of H_2SO_4 :
(3.75 mol) × (98.0768 g/mol) = 367.788 g
Mass of solvent:
1230 − 367.788 = 862.212 g

Molality:
3.75 mol / 0.862212 kg = 4.35 m

Q14. What is the molality of a solution consisting of 1.34 mL of carbon tetrachloride (CCl_4, density= 1.59 g/mL) in 65.0 mL of methylene chloride (CH_2Cl_2, density = 1.33 g/mL)?

Answer.

Moles of CCl_4:
(1.34 mL) × (1.59 g/mL) = 2.1306 g
2.1306 g / 153.823 g/mol = 0.013851 mol
Mass of the methylene chloride:
(65.0 mL) × (1.33 g/mL) = 86.45 g = 0.08645 kg
Molality:
0.013851 mol / 0.08645 kg = 0.160 m.

Q15. Calculate the molality of 2.5 g of ethanoic acid (CH_3COOH) in 75 g of benzene.

Answer.
Molar mass of $C_2H_4O_2$ = 12 × 2 + 1 × 4 + 16 × 2 = 60g mol^{-1}.
Moles of $C_2H_4O_2$ = 2.5g / 60 g mol^{-1} = 0.0417 mol
Mass of benzene in kg = 75 g / 1000 g kg^{-1} = 75 × 10^{-3} kg
Molality of $C_2H_4O_2$ = 0.0417 mol / 75 × 10^{-3} kg = 0.556 mol kg^{-1}.

Practise Questions on Molality

Q1. An aqueous solution of urea containing 18g urea in 1500 cm^3 of the solution has a density equal to 1.052. If the molecular weight of urea is 60, the molality of the solution is:

a) 0.200 m
b) 0.192 m
c) 0.100 m
d) 1.200 m

Correct Answer. (b) 0.192 m
Explanation: Molality of the solution is the ratio of the number of moles of urea to the mass of solvent in kg.
Mass of water = 1578 g −18 g = 1560 g = 1.560 kg (as 1 kg = 1000 g)
Molality = 0.3/1.560 = 0.192 m.

Q2. Calculate the molality of a solution containing 16.5 g of naphthalene ($C_{10}H_8$) in 54.3 g benzene (C_6H_6).

Answer.
molality = moles of naphthalene / kilograms of benzene
(16.5 g / 128.1732 g/mol) / 0.0543 kg = 2.37 m

Q3. Calculate the molality (m) of a 7.55 kg sample of a solution of the solute CH_2Cl_2 (molar mass = 84.93 g/mol) dissolved in the solvent acetone (CH_3COCH_3) if the sample contains 929 g of methylene chloride.

Answer.
mass solvent = 7550 g − 929 g = 6621 g = 6.621 kg
moles solute = 929 g/ 84.93 g/mol = 10.9384 mol
molality = 10.9384 mol / 6.621 kg = 1.65 m

Q4. 560 g of 2 m aqueous solution of urea is mixed with 2480 g of 4 m aqueous solution of urea. What is the molality of the resulting solution?

Answer.
The molar mass of urea = 60 g/mol.
For 2 m solution, 1kg of water will contain 2 mol or 0.12kg urea.
The total mass of the solution will be 1.12 kg.
Hence, 560g of 2m solution will contain 0.06kg urea and 0.5kg water.
For, a 4m solution, 1kg of water will contain 0.24kg of urea.
The total mass of the solution will be 1.24kg. Hence, 2480g of 4m solution will contain 0.48 kg urea and 2kg water.
Total mass of urea = 0.06kg + 0.48kg = 0.54kg = 9moles.
The total mass of water = 0.5kg + 2kg = 2.5kg
The molarity of the solution is m= 9/2.5 =3.6m

Q5. What is the molality of NaCl in an aqueous solution in which the mole fraction of NaCl is 0.100?

Answer.
A mole fraction of 0.100 for NaCl implies a mole fraction of 0.900 for water.
Assume a solution containing 0.100 moles of NaCl and 0.900 moles of water is present.
mass of water present = (0.900 mol) × (18.015 g/mol) = 16.2135 g
molality of solution = 0.100 mol / 0.0162135 kg = 6.1677 m.