Solutions — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · CHEMISTRY · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Atomic masses (g/mol): H 1, C 12, O 16, Na 23, S 32, Cl 35.5. For water take Kf = 1.86 K kg/mol, Kb = 0.52 K kg/mol, and its vapour pressure at 100 °C as 760 mm Hg. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

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Topics covered: Concentration of solutions · Raoult's law · Ideal and non-ideal solutions · Relative lowering of vapour pressure · Elevation of boiling point · Depression of freezing point · Osmotic pressure · Abnormal molar mass and van't Hoff factor

SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

1. The molality of an aqueous solution of NaOH that is 20% NaOH by mass is

(1) 5.0 mol/kg

(2) 6.25 mol/kg

(3) 2.5 mol/kg

(4) 0.25 mol/kg

2. A 3.0 M aqueous solution of NaCl has a density of 1.25 g/mL. Its molality is about (Na = 23, Cl = 35.5)

(1) 3.43 mol/kg

(2) 3.00 mol/kg

(3) 2.40 mol/kg

(4) 2.79 mol/kg

3. The mole fraction of urea in an aqueous solution is 0.10. The molality of the solution is about

(1) 6.17 mol/kg

(2) 5.55 mol/kg

(3) 0.10 mol/kg

(4) 61.7 mol/kg

4. Two liquids A and B form an ideal solution. At a certain temperature their vapour pressures when pure are 90 mm Hg and 30 mm Hg. For an equimolar liquid mixture, the mole fraction of A in the vapour is

(1) 0.50

(2) 0.25

(3) 0.75

(4) 0.60

5. Which of the following mixtures shows a positive deviation from Raoult's law?

(1) Nitric acid + water

(2) Ethanol + water

(3) Phenol + aniline

(4) Acetone + chloroform

6. 18 g of glucose is dissolved in 178.2 g of water at 100 °C. The vapour pressure of the solution is about

(1) 752.4 mm Hg

(2) 759.2 mm Hg

(3) 684.0 mm Hg

(4) 759.9 mm Hg

7. A solution of 0.30 g of a non-volatile solute in 30 g of benzene boils 0.17 K above pure benzene (K_b of benzene = 2.53 K kg/mol). The molar mass of the solute is about

(1) 74 g/mol

(2) 298 g/mol

(3) 15 g/mol

(4) 149 g/mol

8. The freezing point of a 0.1 molal aqueous solution of K_2SO_4, taken as completely dissociated, is (K_f of water = 1.86 K kg/mol)

(1) −0.186 °C

(2) −0.372 °C

(3) −0.558 °C

(4) −0.744 °C

9. Acetic acid dimerises in benzene. In a 0.20 molal solution of acetic acid in benzene, 80% of the acid is dimerised. The depression of freezing point is about (K_f of benzene = 5.12 K kg/mol)

(1) 0.61 K

(2) 1.02 K

(3) 0.41 K

(4) 0.20 K

10. A 5% (w/v) solution of cane sugar (molar mass 342 g/mol) is isotonic with a solution of urea (molar mass 60 g/mol) of strength, in % (w/v),

(1) 5.0%

(2) 28.5%

(3) 0.88%

(4) 1.75%

11. In a dilute aqueous solution, $AlCl_3$ is 75% dissociated. The van't Hoff factor of the solution is

(1) 3.25

(2) 4.00

(3) 2.50

(4) 1.75

12. Liquids A and B form an ideal solution. At a certain temperature the vapour pressures of pure A and pure B are 120 mm Hg and 60 mm Hg. A mixture of A and B has a total vapour pressure of 100 mm Hg at that temperature. The mole fraction of A in the liquid is about

(1) 0.33

(2) 0.50

(3) 0.83

(4) 0.67

13. Which of the following is NOT true of the formation of an ideal solution from its components at constant temperature and pressure?

(1) $\Delta H(\text{mix}) = 0$

(2) $\Delta V(\text{mix}) = 0$

(3) $\Delta S(\text{mix}) = 0$

(4) $\Delta G(\text{mix}) < 0$

14. Equal molal (0.01 mol/kg) aqueous solutions of the following are prepared. Taking each electrolyte as completely dissociated, which solution has the lowest freezing point?

(1) Glucose

(2) NaCl

(3) $Al_2(SO_4)_3$

(4) $CaCl_2$

15. The volume of concentrated sulphuric acid (98% H_2SO_4 by mass, density 1.80 g/mL) needed to prepare 1.0 L of 0.90 M H_2SO_4 is

(1) 25 mL

(2) 100 mL

(3) 50 mL

(4) 18 mL

16. Assertion A: The molality of a solution does not change with temperature, but its molarity does.
Reason R: Molarity is defined per unit volume of solution, and the volume of a solution changes with temperature.
In the light of the above statements, choose the correct answer from the options given below:

(1) A is true but R is false

(2) A is false but R is true

(3) Both A and R are true but R is NOT the correct explanation of A

(4) Both A and R are true and R is the correct explanation of A

17. A solution of two volatile liquids shows a large negative deviation from Raoult's law. Which of the following is true for it?

(1) It forms a minimum-boiling azeotrope

(2) $\Delta H(\text{mix}) > 0$

(3) It forms a maximum-boiling azeotrope

(4) $\Delta V(\text{mix}) > 0$

18. 1.0 g of a protein dissolved in water to make 100 mL of solution gives an osmotic pressure of 2.46×10^{-3} atm at 300 K. The molar mass of the protein is about (R = 0.0821 L atm/(K mol))

(1) 1.0×10^4 g/mol

(2) 1.0×10^5 g/mol

(3) 1.0×10^6 g/mol

(4) 2.5×10^4 g/mol

19. A weak monobasic acid HX is 5% dissociated in a 0.20 molal aqueous solution. The freezing point of the solution is about (K_f of water = 1.86 K kg/mol)

(1) −0.372 °C

(2) −0.391 °C

(3) −0.744 °C

(4) −0.019 °C

20. Consider the following statements about colligative properties.

(A) They depend on the number of solute particles, not on their nature.

(B) The elevation of boiling point is a consequence of the lowering of vapour pressure by a non-volatile solute.

(C) Equimolal solutions of NaCl and glucose in water have the same freezing point.

(D) In reverse osmosis, a pressure larger than the osmotic pressure is applied on the solution side.

(E) The value of K_f depends on the solute dissolved.

Choose the correct answer from the options given below:

(1) (A), (B) and (D) only

(2) (A), (C) and (E) only

(3) (B), (D) and (E) only

(4) (A), (B), (C) and (D) only

SECTION B (Q21–25) · Numerical value · +4 / 0 / −1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

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21. The mass (in g) of ethylene glycol ($C_2H_6O_2$) that must be dissolved in 5.0 kg of water to lower its freezing point to −2.79 °C is _____ (K_f of water = 1.86 K kg/mol).

Answer: _____

22. The osmotic pressure (in bar) of a 0.12 M aqueous solution of $CaCl_2$ at 300 K, taking $CaCl_2$ as completely dissociated, is _____ (to the nearest integer; R = 0.083 L bar/(K mol)).

Answer: _____

23. The mass (in g) of urea (molar mass 60 g/mol) that must be dissolved in 900 g of water to lower its vapour pressure by 2% is _____ (to the nearest integer).

Answer: _____

24. In an aqueous solution, $K_4[Fe(CN)_6]$ is 60% dissociated into K^+ and $[Fe(CN)_6]^{4-}$ ions. Its van't Hoff factor is x/10. The value of x is _____.

Answer: _____

25. The elevation of the boiling point of a 0.050 molal aqueous solution of Na_2SO_4, taken as completely dissociated, is $x \times 10^{-2}$ K. The value of x is _____ (to the nearest integer; K_b of water = 0.52 K kg/mol).

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(2)	(4)	(1)	(3)	(2)	(1)	(4)	(3)	(1)	(3)

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(1)	(4)	(3)	(3)	(3)	(4)	(3)	(2)	(2)	(1)

Q21	Q22	Q23	Q24	Q25
465	9	61	34	8

WORKED SOLUTIONS

Q1. Answer (2). 100 g of solution has 20 g NaOH (0.5 mol) in 80 g of water. Molality = 0.5/0.080 = 6.25 mol/kg.

Q2. Answer (4). 1 L of solution weighs 1250 g and holds 3 × 58.5 = 175.5 g NaCl, so the water is 1074.5 g. Molality = 3/1.0745 ≈ 2.79 mol/kg.

Q3. Answer (1). Take 1 mol in all: 0.10 mol urea and 0.90 mol water (16.2 g). Molality = 0.10/0.0162 ≈ 6.17 mol/kg.

Q4. Answer (3). $p_A = 0.5 \times 90 = 45$, $p_B = 0.5 \times 30 = 15$, total 60 mm Hg. In the vapour, $y_A = 45/60 = 0.75$: the vapour is richer in the more volatile liquid.

Q5. Answer (2). Ethanol molecules are hydrogen bonded to one another; water breaks some of these bonds without replacing them fully, so the escaping tendency rises and the vapour pressure is higher than Raoult's law predicts (it forms a minimum-boiling azeotrope with about 95% ethanol). HNO_3 + water, phenol + aniline (O–H···N bonds) and acetone + chloroform (C–H···O bonds) attract each other more strongly than like molecules: negative deviations.

Q6. Answer (1). Glucose: 18/180 = 0.1 mol; water: 178.2/18 = 9.9 mol. Relative lowering = x(solute) = 0.1/10 = 0.01. At 100 °C, p° = 760 mm Hg, so p = 760 × 0.99 = 752.4 mm Hg.

Q7. Answer (4). $\Delta T_b = K_b\, m$, so m = 0.17/2.53 mol/kg. M = (0.30 g/0.030 kg)/m = 10 × 2.53/0.17 ≈ 149 g/mol.

Q8. Answer (3). $K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$: i = 3. $\Delta T_f = iK_f\, m = 3 \times 1.86 \times 0.1 = 0.558$ K, so the solution freezes at −0.558 °C.

Q9. Answer (1). For $2A \rightleftharpoons A_2$ with degree of association α: $i = 1 - \alpha/2 = 1 - 0.4 = 0.6$. $\Delta T_f = 0.6 \times 5.12 \times 0.20 \approx 0.61$ K. The apparent molar mass is 60/0.6 = 100 g/mol.

Q10. Answer (3). Isotonic solutions of non-electrolytes have equal molar concentrations: 5/342 = x/60, so x = 300/342 ≈ 0.88% (w/v).

Q11. Answer (1). $AlCl_3 \rightarrow Al^{3+} + 3Cl^-$ gives ν = 4 ions. $i = 1 + \alpha(\nu - 1) = 1 + 0.75 \times 3 = 3.25$.

Q12. Answer (4). $p = 60 + (120 - 60)x_A = 100$, so $x_A = 40/60 \approx 0.67$.

Q13. Answer (3). For an ideal solution ΔH(mix) = 0 and ΔV(mix) = 0, but mixing increases disorder: $\Delta S(\text{mix}) = -R \Sigma\, n\, x \ln x > 0$, so $\Delta G(\text{mix}) = -T\Delta S(\text{mix}) < 0$.

Q14. Answer (3). The depression is proportional to i: glucose 1, NaCl 2, $CaCl_2$ 3, $Al_2(SO_4)_3$ 5 ($2Al^{3+} + 3SO_4^{2-}$). $Al_2(SO_4)_3$ lowers the freezing point most.

Q15. Answer (3). Concentrated acid: 1000 × 1.80 × 0.98/98 = 18 M. V = 0.90 × 1000/18 = 50 mL.

Q16. Answer (4). Molality uses masses (moles of solute per kg of solvent), which do not change on heating; molarity uses the volume of solution, which expands. Both are true and R explains A.

Q17. Answer (3). Negative deviation means stronger A–B attraction: heat is given out ($\Delta H(\text{mix}) < 0$), the volume contracts ($\Delta V(\text{mix}) < 0$), and the vapour pressure curve has a minimum, i.e. the boiling point has a maximum at the azeotropic composition (as for HNO_3 + water).

Q18. Answer (2). $\pi = (w/M)RT/V$, so $M = wRT/(\pi V) = 1.0 \times 0.0821 \times 300/(2.46 \times 10^{-3} \times 0.100) \approx 1.0 \times 10^5$ g/mol. Osmotic pressure is the method of choice for such large molecules, since ΔT_f would be only about 2×10^{-4} K.

Q19. Answer (2). $HX \rightleftharpoons H^+ + X^-$: $i = 1 + \alpha = 1.05$. $\Delta T_f = 1.05 \times 1.86 \times 0.20 \approx 0.391$ K, so the solution freezes at about -0.391 °C.

Q20. Answer (1). (A), (B) and (D) are true; (D) is how sea water is desalinated. (C) is false: NaCl gives two ions ($i \approx 2$), so its freezing point is lower. (E) is false: K_f is a property of the solvent only.

Q21. Answer 465. $m = \Delta T_f/K_f = 2.79/1.86 = 1.5$ mol/kg, i.e. 7.5 mol in 5 kg. Mass $= 7.5 \times 62 = 465$ g.

Q22. Answer 9. $CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$: $i = 3$. $\pi = iCRT = 3 \times 0.12 \times 0.083 \times 300 = 8.96$ bar, i.e. 9.

Q23. Answer 61. Relative lowering $= n_2/(n_1 + n_2) = 0.02$ with $n_1 = 900/18 = 50$ mol: $n_2 = 0.02 \times 50/0.98 \approx 1.02$ mol $= 61.2$ g, i.e. 61.

Q24. Answer 34. $K_4[Fe(CN)_6] \rightarrow 4K^+ + [Fe(CN)_6]^{4-}$ gives 5 ions. $i = 1 + 0.6 \times (5 - 1) = 3.4 = 34/10$.

Q25. Answer 8. $i = 3$. $\Delta T_b = 3 \times 0.52 \times 0.050 = 0.078$ K $= 7.8 \times 10^{-2}$ K, i.e. 8.

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: quantities were recomputed from the data given, and structures, configurations and options were derived from rules coded separately from the questions.