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Purification and Characterisation of Organic Compounds — 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. 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: Purification methods · Chromatography · Qualitative analysis · Estimation of carbon and hydrogen · Estimation of nitrogen · Estimation of halogens, sulfur and phosphorus · Empirical and molecular formula

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

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

1. Glycerol (b.p. 563 K) decomposes at its boiling point. The method best suited to purify it is

(1) steam distillation

(2) fractional distillation

(3) distillation under reduced pressure

(4) sublimation

2. Aniline is separated from an aniline–water mixture by

(1) steam distillation

(2) simple distillation

(3) sublimation

(4) crystallisation

3. Two miscible liquids A (b.p. 350 K) and B (b.p. 365 K) are to be separated. The most suitable method is

(1) simple distillation

(2) steam distillation

(3) distillation under reduced pressure

(4) fractional distillation

4. Which of the following mixtures can be separated by sublimation?

(1) Benzoic acid and sugar crystallised together from water

(2) Naphthalene and sodium chloride

(3) Ethanol and water

(4) Aniline and water

5. In a thin-layer chromatogram the solvent front moved 12.0 cm from the base line and the spot of compound X moved 3.6 cm. The retardation factor (Rf) of X is

(1) 3.33

(2) 0.30

(3) 0.70

(4) 0.43

6. Three compounds P, Q and R are run on the same silica gel TLC plate with the same solvent. Their Rf values are 0.65, 0.42 and 0.18 respectively. The compound most strongly adsorbed on the silica gel is

(1) P

(2) Q

(3) R

(4) all are adsorbed equally

7. In Lassaigne's test for nitrogen, the Prussian blue colour is due to the formation of

(1) $Na_4[Fe(CN)_6]$

(2) $Fe_4[Fe(CN)_6]_3$

(3) $Fe(SCN)_3$

(4) $Na_3[Fe(CN)_5NOS]$

8. When an organic compound containing both nitrogen and sulfur is fused with a little sodium, the extract gives a blood-red colour with $FeCl_3$ solution. The species responsible is

(1) $[Fe(CN)_6]^{4-}$

(2) $Fe_4[Fe(CN)_6]_3$

(3) $[Fe(SCN)]^{2+}$

(4) $[Fe(CN)_5NOS]^{4-}$

9. The sodium fusion extract of a compound gives a violet colour with sodium nitroprusside. This shows the presence of

(1) nitrogen

(2) a halogen

(3) phosphorus

(4) sulfur

10. Assertion A: In Lassaigne's test for halogens, the sodium fusion extract is boiled with dilute nitric acid before silver nitrate is added.
Reason R: Boiling with nitric acid decomposes any NaCN and Na_2S present, which would otherwise interfere with the test.
In the light of the above statements, choose the correct answer from the options given below:

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

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

(3) A is true but R is false

(4) A is false but R is true

11. In the test for carbon and hydrogen, the compound is heated with copper(II) oxide. The gas that turns lime water milky and the substance that turns blue are, respectively,

(1) CO_2 and anhydrous $CuSO_4$

(2) CO and anhydrous $CuSO_4$

(3) CO_2 and CuO

(4) H_2O and anhydrous $CuSO_4$

12. In Dumas' method, 0.30 g of an organic compound gave 50.0 mL of nitrogen collected over water at 300 K and 715 mm Hg. The aqueous tension at 300 K is 15 mm Hg. The percentage of nitrogen in the compound is about (molar volume at STP 22400 mL)

(1) 14.0

(2) 19.5

(3) 8.7

(4) 17.5

13. Kjeldahl's method can be used to estimate nitrogen in

(1) nitrobenzene

(2) pyridine

(3) acetamide

(4) azobenzene

14. In Carius' method, 0.25 g of an organic compound gave 0.4305 g of silver bromide. The percentage of bromine in the compound is about (Ag = 108, Br = 80)

(1) 73.3

(2) 45.8

(3) 36.6

(4) 80.0

15. In Carius' method for sulfur, 0.160 g of an organic compound gave 0.4893 g of barium sulfate. The percentage of sulfur in the compound is about (Ba = 137, S = 32, O = 16)

(1) 14.0

(2) 21.0

(3) 42.0

(4) 32.0

16. 0.200 g of an organic compound, after oxidation of its phosphorus to phosphoric acid and precipitation, gave 0.111 g of $Mg_2P_2O_7$. The percentage of phosphorus in the compound is about (Mg = 24, P = 31, O = 16)

(1) 7.8

(2) 27.9

(3) 31.0

(4) 15.5

17. An organic compound contains C 54.55%, H 9.09% and O 36.36% by mass. Its vapour density is 44. Its molecular formula is

(1) C_2H_4O

(2) $C_4H_8O_2$

(3) $C_3H_4O_3$

(4) $C_5H_{12}O$

18. 10.0 g of a solute is dissolved in 100 mL of water. Its distribution coefficient between ether and water, K = (concentration in ether)/(concentration in water), is 4. The total mass of solute extracted by two successive extractions with 50 mL of ether each is about

(1) 6.67 g

(2) 8.89 g

(3) 8.00 g

(4) 9.60 g

19. Which of the following statements about chromatography is NOT correct?

(1) In column chromatography the least strongly adsorbed component is eluted first.

(2) Paper chromatography is a form of partition chromatography.

(3) Colourless compounds on a TLC plate can be seen under ultraviolet light or by spraying a suitable reagent.

(4) In paper chromatography the stationary phase is the moving solvent.

20. 0.25 g of an organic compound containing C, H and O gave on complete combustion 0.55 g of CO_2 and 0.27 g of H_2O. The percentages of carbon and hydrogen in the compound are, respectively,

(1) 60.0 and 12.0

(2) 15.0 and 3.0

(3) 60.0 and 6.0

(4) 40.9 and 12.0

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. In Kjeldahl's method, the ammonia evolved from 0.60 g of an organic compound was absorbed in 50 mL of 0.5 M H_2SO_4. The acid left over needed 30 mL of 1.0 M NaOH for neutralisation. The percentage of nitrogen in the compound (to the nearest integer) is _____.

Answer: _____

22. In Dumas' method, 0.25 g of an organic compound gave 45 mL of nitrogen collected over water at 27 °C and 756 mm Hg (aqueous tension 26 mm Hg). The percentage of nitrogen in the compound (to the nearest integer) is _____. (Molar volume at STP = 22400 mL)

Answer: _____

23. In Carius' method, 0.180 g of an organic compound gave 0.287 g of AgCl. The percentage of chlorine in the compound (to the nearest integer) is _____. (Ag = 108, Cl = 35.5)

Answer: _____

24. 0.37 g of an organic compound containing C, H and O gives on complete combustion 0.88 g of CO_2 and 0.45 g of H_2O. Its molar mass is 74 g/mol. The total number of atoms in one molecule of the compound is _____.

Answer: _____

25. The number of the following compounds whose sodium fusion extract gives Prussian blue in Lassaigne's test for nitrogen is _____.

urea, hydrazine, hydroxylamine, aniline, glycine, pyridine, ammonium chloride, nitrobenzene, acetamide

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

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

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

Q21	Q22	Q23	Q24	Q25
47	20	39	15	6

WORKED SOLUTIONS

Q1. Answer (3). Lowering the external pressure lowers the boiling point, so glycerol can be distilled well below 563 K, where it does not decompose. (The same method is used to concentrate sugar-cane juice in sugar factories.)

Q2. Answer (1). Aniline is immiscible with water and volatile in steam. In steam distillation the mixture boils when p(water) + p(aniline) = atmospheric pressure, i.e. below 373 K, so aniline distils over without decomposing.

Q3. Answer (4). The boiling points differ by only 15 K, so a single vaporisation does not separate them; the repeated vaporisation and condensation in a fractionating column does. (Simple distillation needs a large difference in boiling points.)

Q4. Answer (2). On heating, naphthalene passes directly from solid to vapour and condenses back on a cool surface, while NaCl stays behind. The other mixtures contain no subliming component.

Q5. Answer (2). Rf = distance moved by the substance/distance moved by the solvent front = 3.6/12.0 = 0.30.

Q6. Answer (3). In adsorption chromatography the more strongly a compound is adsorbed on the stationary phase, the less it moves with the solvent. R has the lowest Rf (0.18), so it is held most strongly.

Q7. Answer (2). NaCN from the fusion gives $Na_4[Fe(CN)_6]$ with $FeSO_4$; on boiling and acidifying, some Fe^{2+} is oxidised to Fe^{3+}, which forms iron(III) hexacyanidoferrate(II), $Fe_4[Fe(CN)_6]_3$ (Prussian blue).

Q8. Answer (3). With limited sodium, N and S together form NaSCN, which gives the blood-red $[Fe(SCN)]^{2+}$ ion with Fe^{3+}. (With excess sodium, NaSCN breaks down to NaCN and Na_2S, which give the separate tests.)

Q9. Answer (4). Na_2S from the fusion reacts with sodium nitroprusside to give the violet complex $[Fe(CN)_5NOS]^{4-}$. This (or a black precipitate of PbS with lead acetate) is the test for sulfur.

Q10. Answer (1). If N or S is present, NaCN and Na_2S would give precipitates (AgCN, Ag_2S) with $AgNO_3$ and be mistaken for silver halide. Boiling with HNO_3 drives them off as HCN and H_2S. Both are true and R explains A.

Q11. Answer (1). C is oxidised to CO_2, which turns lime water milky ($CaCO_3$). H is oxidised to H_2O, which turns white anhydrous $CuSO_4$ blue ($CuSO_4·5H_2O$).

Q12. Answer (4). Pressure of dry N_2 = 715 − 15 = 700 mm. V(STP) = 50.0 × (700/760) × (273/300) = 41.9 mL. Mass of N_2 = 28 × 41.9/22400 = 0.0524 g. %N = 0.0524/0.30 × 100 = 17.5.

Q13. Answer (3). In Kjeldahl's method the nitrogen must be converted to $(NH_4)_2SO_4$ by heating with concentrated H_2SO_4. Nitrogen of nitro and azo groups, and nitrogen in a ring such as pyridine, is not converted. Amide nitrogen (acetamide) is.

Q14. Answer (1). Mass of Br = 0.4305 × 80/188 = 0.1832 g. %Br = 0.1832/0.25 × 100 = 73.3.

Q15. Answer (3). Sulfur is oxidised to H_2SO_4 and precipitated as $BaSO_4$ (M = 233). Mass of S = 0.4893 × 32/233 = 0.0672 g. %S = 0.0672/0.160 × 100 = 42.0.

Q16. Answer (4). M($Mg_2P_2O_7$) = 48 + 62 + 112 = 222, containing 62 g P. Mass of P = 0.111 × 62/222 = 0.0310 g. %P = 0.0310/0.200 × 100 = 15.5.

Q17. Answer (2). Mole ratio C : H : O = 54.55/12 : 9.09/1 : 36.36/16 = 4.55 : 9.09 : 2.27 = 2 : 4 : 1, so the empirical formula is C_2H_4O (M = 44). Molar mass = 2 × 44 = 88, so the formula is $(C_2H_4O)_2 = C_4H_8O_2$.

Q18. Answer (2). After one extraction the fraction left in water is 1/(1 + K × 50/100) = 1/3. After two it is $(1/3)^2$ = 1/9, leaving 1.11 g; extracted 10.0 − 1.11 = 8.89 g. (A single 100 mL portion would extract only 10 × 4/5 = 8.00 g; repeated small portions are better.)

Q19. Answer (4). In paper chromatography the stationary phase is the water held in the cellulose of the paper; the solvent is the mobile phase. The other three statements are correct.

Q20. Answer (1). Mass of C = 0.55 × 12/44 = 0.15 g (60.0%). Mass of H = 0.27 × 2/18 = 0.03 g (12.0%). Oxygen by difference: 28.0%. (Using 1/18 instead of 2/18 for H gives 6.0%.)

Q21. Answer 47. H^+ taken: 50 × 0.5 × 2 = 50 mmol. H^+ left over: 30 × 1.0 = 30 mmol. NH_3 = 50 − 30 = 20 mmol, i.e. 0.280 g N. %N = 0.280/0.60 × 100 = 46.7, i.e. 47.

Q22. Answer 20. p(N_2) = 756 − 26 = 730 mm. V(STP) = 45 × (730/760) × (273/300) = 39.33 mL. Mass = 28 × 39.33/22400 = 0.0492 g. %N = 0.0492/0.25 × 100 = 19.7, i.e. 20.

Q23. Answer 39. Mass of Cl = 0.287 × 35.5/143.5 = 0.0710 g. %Cl = 0.0710/0.180 × 100 = 39.4, i.e. 39.

Q24. Answer 15. C = 0.88 × 12/44 = 0.24 g (0.020 mol), H = 0.45 × 2/18 = 0.05 g (0.050 mol), O = 0.37 − 0.29 = 0.08 g (0.005 mol). Ratio 4 : 10 : 1, empirical formula $C_4H_{10}O$ (M = 74) = molecular formula: 4 + 10 + 1 = 15 atoms.

Q25. Answer 6. Fusion converts N to NaCN only if the compound also contains carbon. Urea, aniline, glycine, pyridine, nitrobenzene and acetamide contain both C and N. Hydrazine (N_2H_4), hydroxylamine (NH_2OH) and NH_4Cl contain no carbon, so no cyanide forms. Answer 6.

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: percentages were recomputed from the masses and gas volumes given (corrected to STP), titrations by counting millimoles, formulae by finding the smallest whole-number mole ratio, extraction by applying the distribution law portion by portion, and method questions against a separate table of the conditions each method needs.