Why Carboxylic Acids Boil So High: Hydrogen-Bonded Dimers

Four molecules of about the same mass boil from 0 °C to 118 °C. Carboxylic acids win because two hydrogen bonds join them into dimers that survive even in the vapour; the same dimers double acetic acid's measured molar mass in benzene.

Name: Date: Score: ____ / 13

A. Fill in the blanks

1. Two acetic acid molecules held by two hydrogen bonds form a ____.

2. Acetic acid's molar mass measured in benzene is about ____.

3. Aliphatic acids are miscible with water up to ____ carbons.

B. True or False

4. Carboxylic acids boil higher than alcohols of similar molar mass. True / False

5. Hydrogen bonds in carboxylic acids are completely broken in the vapour phase. True / False

6. Benzoic acid dissolves readily in cold water. True / False

C. Assertion and reason

7. Assertion (A): Acetic acid shows an abnormal molar mass in benzene.
Reason (R): It dimerises through hydrogen bonds.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

8. Assertion (A): Hexanoic acid is less soluble in water than ethanoic acid.
Reason (R): Its larger hydrocarbon part does not hydrogen-bond with water.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

D. Choose the correct option

9. Increasing b.p.:

(a) butane < propanal < propan-1-ol < ethanoic acid
(b) propanal < butane < ethanoic acid < propan-1-ol
(c) ethanoic acid < propan-1-ol < propanal < butane
(d) butane < propan-1-ol < propanal < ethanoic acid

Answer: _____

10. In the dimer, the hydrogen of O–H bonds to:

(a) the CH_3 carbon
(b) the C=O oxygen of the other molecule
(c) the other O–H hydrogen
(d) the carboxyl carbon

Answer: _____

E. Numerical problems

11. How many hydrogen bonds hold one carboxylic acid dimer together?

F. Short answer questions

12. Draw the acetic acid dimer and explain why acetic acid boils at 118 °C while propan-1-ol boils at 97 °C.

G. Match the columns

13. Match each item in Column A with the correct item in Column B.

Column A	Column B	Your answer
1. butane	(a) 49 °C	1 → ____
2. propanal	(b) 118 °C	2 → ____
3. propan-1-ol	(c) ≈ 0 °C	3 → ____
4. ethanoic acid	(d) 97 °C	4 → ____

Detailed solutions

1. dimer

2. 120

3. four

4. True. More extensive hydrogen-bonded association: dimers.

5. False. Most acids remain dimers in the vapour.

6. False. It is nearly insoluble in cold water.

7. (a) R explains A.

8. (a) R explains A.

9. (a) butane < propanal < propan-1-ol < ethanoic acid. No H-bonding < dipole–dipole < H-bonding < dimers.

10. (b) the C=O oxygen of the other molecule. O–H···O=C.

11. O–H···O=C, twice. **Answer: 2**

12. Two CH_3COOH molecules joined by two O–H···O=C hydrogen bonds; this stronger, more extensive association (persisting even in the vapour) needs more energy to overcome than the single H-bonds of the alcohol.

13. 1 → (c), 2 → (a), 3 → (d), 4 → (b). Each compound matches its boiling point.