Esterification and the C–OH Swap: Esters, Acid Chlorides, Anhydrides, Amides

Fruity esters from an acid and an alcohol, with the acid-catalysed mechanism drawn arrow by arrow, and three more ways to replace the –OH of –COOH: acid chlorides (best with $SOCl_2$), anhydrides and amides.

Name: Date: Score: ____ / 15

A. Fill in the blanks

1. Acid + alcohol with conc. H_2SO_4 gives an ____ and water.

2. The best reagent for converting RCOOH to RCOCl is ____.

3. Dehydration of acetic acid with P_2O_5 gives acetic ____.

4. Heating ammonium acetate gives ____.

B. True or False

5. Esterification is reversible. True / False

6. In esterification the water's oxygen comes from the alcohol. True / False

7. PCl_3 converts RCOOH to RCOCl with H_3PO_3 as by-product. True / False

C. Assertion and reason

8. Assertion (A): The carbonyl oxygen is protonated first in esterification.
Reason (R): Protonation makes the carbonyl carbon more electrophilic.

(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: _____

9. Assertion (A): $SOCl_2$ gives purer acid chlorides than PCl_5.
Reason (R): SO_2 and HCl escape as gases.

(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

10. The leaving group in the esterification mechanism is:

(a) OH^-
(b) H_2O
(c) H^+
(d) $R'O^-$

Answer: _____

11. $CH_3COOH + SOCl_2$ gives:

(a) $CH_3COCl + SO_2 + HCl$
(b) CH_3CHO
(c) CH_3COOCH_3
(d) CH_3CONH_2

Answer: _____

12. Which pushes the ester equilibrium forward?

(a) adding water (b) removing water

(c) adding ester (d) cooling to 0 °C

Answer: _____

E. Numerical problems

13. How many molecules of RCOOH react with one PCl_3?

F. Short answer questions

14. Write the mechanism of the acid-catalysed esterification of CH_3COOH with C_2H_5OH.

G. Match the columns

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

Column A	Column B	Your answer
1. R′OH, H^+	(a) anhydride	1 → ____
2. $SOCl_2$	(b) ester	2 → ____
3. P_2O_5	(c) amide	3 → ____
4. NH_3, heat	(d) acid chloride	4 → ____

Detailed solutions

1. ester

2. $SOCl_2$

3. anhydride

4. acetamide

5. True. Remove water or use excess alcohol to push it forward.

6. False. It comes from the acid's –OH.

7. True. $3RCOOH + PCl_3 \rightarrow 3RCOCl + H_3PO_3$.

8. (a) R explains A.

9. (a) R explains A.

10. (b) H_2O. $–OH_2^+$ leaves as neutral water.

11. (a) $CH_3COCl + SO_2 + HCl$. An acid chloride; the other products are gases.

12. (b) removing water. Le Chatelier: remove a product.

13. $3RCOOH + PCl_3 \rightarrow 3RCOCl + H_3PO_3$. **Answer: 3**

14. Protonate C=O; C_2H_5OH's O lone pair adds to C (C=O π to O); proton shift gives $–OH_2^+$; an OH lone pair re-forms C=O as H_2O leaves; $-H^+$ gives $CH_3COOC_2H_5$.

15. 1 → (b), 2 → (d), 3 → (a), 4 → (c). Each reagent replaces the OH with that group.