Nucleophilic Addition Reactions: One Carbonyl, Five Pathways

Every nucleophilic addition reaction of aldehydes and ketones in one place: HCN, $NaHSO_3$, Grignard reagents, alcohols, and the addition–elimination of ammonia derivatives, with the product each one gives.

Name: Date: Score: ____ / 19

A. Fill in the blanks

1. With HCN, the species that actually attacks the carbonyl carbon is ____.

2. An aldehyde with $NaHSO_3$ gives a crystalline ____ addition compound.

3. A ketone with a Grignard reagent, then H_3O^+, gives a ____ alcohol.

4. One molecule of alcohol adds to an aldehyde to give a ____.

5. NH_2OH converts an aldehyde or ketone into an ____.

B. True or False

6. Pure HCN adds to carbonyl compounds very slowly; a base speeds it up. True / False

7. In the bisulphite adduct, the HSO_3^- ion bonds to carbon through its oxygen. True / False

8. Formaldehyde with CH_3MgBr, then H_3O^+, gives a primary alcohol. True / False

9. The reaction of carbonyl compounds with $H_2N–Z$ is a simple addition. True / False

C. Assertion and reason

10. Assertion (A): Ketones give the bisulphite addition compound less readily than aldehydes.
Reason (R): The two alkyl groups crowd the carbonyl carbon.

(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: _____

11. Assertion (A): 2,4-DNP gives a coloured precipitate with aldehydes and ketones.
Reason (R): The C=O group becomes $C=N–NHC_6H_3(NO_2)_2$ with loss of 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

12. CH_3CHO + HCN (base) gives:

(a) $CH_3CH(OH)CN$
(b) CH_3CH_2CN
(c) CH_3CONH_2
(d) $CH_3CH=NOH$

Answer: _____

13. Which gives a 2° alcohol with CH_3MgBr, then H_3O^+?

(a) HCHO
(b) CH_3CHO
(c) CH_3COCH_3
(d) CO_2

Answer: _____

14. An acetal has on one carbon:

(a) OH and OR
(b) two OR groups
(c) OH and CN
(d) C=N

Answer: _____

15. Semicarbazide gives a:

(a) semicarbazone
(b) hydrazone
(c) oxime
(d) cyanohydrin

Answer: _____

E. Numerical problems

16. How many carbon groups are on the OH-bearing carbon of the alcohol from acetone + CH_3MgBr?

17. How many molecules of CH_3OH are used to turn one CH_3CHO into its acetal?

F. Short answer questions

18. Write the products of CH_3CHO with (i) HCN (ii) NH_2OH (iii) 2 CH_3OH in dry HCl, and name each.

G. Match the columns

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

Column A	Column B	Your answer
1. HCN	(a) bisulphite adduct	1 → ____
2. $NaHSO_3$	(b) alcohol	2 → ____
3. RMgX, H_3O^+	(c) hydrazone	3 → ____
4. NH_2NH_2	(d) cyanohydrin	4 → ____

Detailed solutions

1. CN^-

2. bisulphite

3. tertiary (3°)

4. hemiacetal

5. oxime

6. True. The base makes CN^-, the stronger nucleophile.

7. False. It bonds through sulphur: $R_2C(OH)SO_3^-Na^+$.

8. True. HCHO gives 1°, other aldehydes 2°, ketones 3°.

9. False. It is addition followed by loss of water: addition–elimination.

10. (a) R explains A.

11. (a) R explains A.

12. (a) $CH_3CH(OH)CN$. CN and OH on the same carbon: a cyanohydrin.

13. (b) CH_3CHO. Other aldehydes give secondary alcohols.

14. (b) two OR groups. Hemiacetal: OH + OR; acetal: OR + OR.

15. (a) semicarbazone. $NH_2NHCONH_2 \rightarrow >C=N–NHCONH_2$.

16. $(CH_3)_3COH$: three CH_3 groups. **Answer: 3**

17. One gives the hemiacetal, the second the acetal. **Answer: 2**

18. (i) $CH_3CH(OH)CN$, a cyanohydrin (ii) $CH_3CH=NOH$, an oxime (iii) $CH_3CH(OCH_3)_2$, an acetal

19. 1 → (d), 2 → (a), 3 → (b), 4 → (c). Each reagent matches its product.