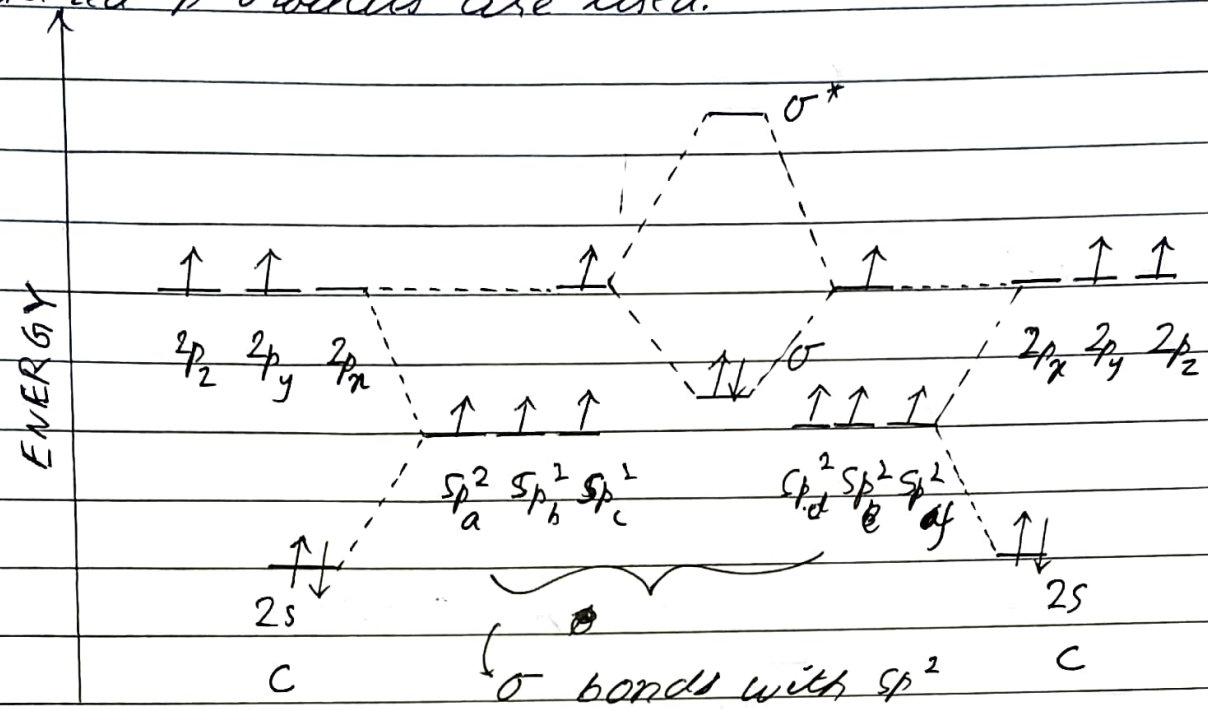
1. Unhybridized 2p-orbitals are used.



C*–C* bond is weaker than a normal C–C bond, because it has 0% s-character, while an sp^3-sp^3 bond has 25% s-character

Bond strength ∝ s character

Since the angle is specified as 120°, we assign a hybridisation of C* as sp^2, where the unhybridized p-orbitals of each C* form a head-on overlap to generate a C*–C* σ bond.

2. (a) $H_3C-\ddot{N}=\overset{\oplus}{N}: \longleftrightarrow H_3C-\overset{\oplus}{N}\equiv N:$ ✓

(b) $H-C(=\ddot{O}:)-\overset{\oplus}{O}-H \longleftrightarrow H-\overset{O}{\overset{\|}{C}}-\ddot{O}-H$ ✓

(c) $H_2\overset{\oplus}{C}-\underset{\ominus}{\overset{\cdot\cdot}{C}}H_2 \longleftrightarrow H_2C=CH_2$ ✓

(d) $H_2\overset{\oplus}{C}-CH=CH-\underset{\ominus}{\overset{\cdot\cdot}{C}}H_2 \longleftrightarrow H_2C-\underset{\ominus}{\overset{\cdot\cdot}{C}}H-CH=CH_2$

(I) (II)

$H_2C=CH-\underset{\ominus}{\overset{\cdot\cdot}{C}}H-\overset{\oplus}{C}H_2$ (IV)

$H_2\overset{\ominus}{C}-CH=\overset{\oplus}{C}H-CH_2$ (III)

$H_2C=CH-\overset{\ominus}{C}H=\overset{\oplus}{C}H_2$ (IV)

III > II = V > IV = I

(e) $H_2\overset{\oplus}{C}-CH=CH-\ddot{O}:\longleftrightarrow H_2\overset{\oplus}{C}-\underset{\ominus}{\overset{\cdot\cdot}{C}}H-CH=\ddot{O}:$

(I) (II)

$H_2\overset{\ominus}{C}-CH=\overset{\oplus}{C}H-\ddot{O}: \longleftrightarrow H_2C=CH-CH=\ddot{O}:$ (III)

(IV)

$H_2C=CH-\underset{\ominus}{\overset{\cdot\cdot}{C}}H-\ddot{O}:$ (V)

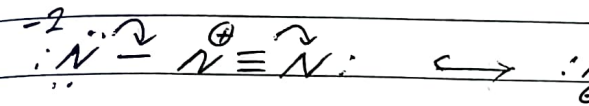
III > II > V > I > IV

(f) $H_2\overset{\ominus}{C}-\overset{\oplus}{\overset{O}{\overset{\|}{C}}}-H \longleftrightarrow H_2C=\underset{\ominus}{\overset{\cdot\cdot}{C}}-H$ ✓

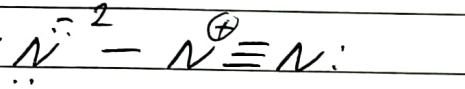
(g) $H-\overset{\oplus}{C}=\ddot{O}: \longleftrightarrow H-C\equiv\overset{\oplus}{O}:$ ✓

(h) $H_2C-\overset{\oplus}{\ddot{O}}H \longleftrightarrow H_2C=\overset{\oplus}{O}H$ ✓

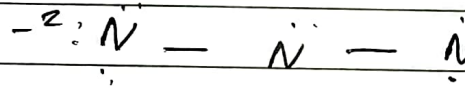
(i) $H_2\overset{\ominus}{C}-N=\overset{\oplus}{N}H_2 \longleftrightarrow H_2C=N-\ddot{N}H_2$

3. (a) 

(b) Not resonance structure.



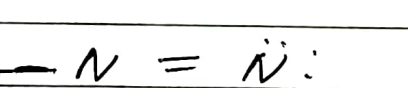
F.C. = −1



F.C. = −4

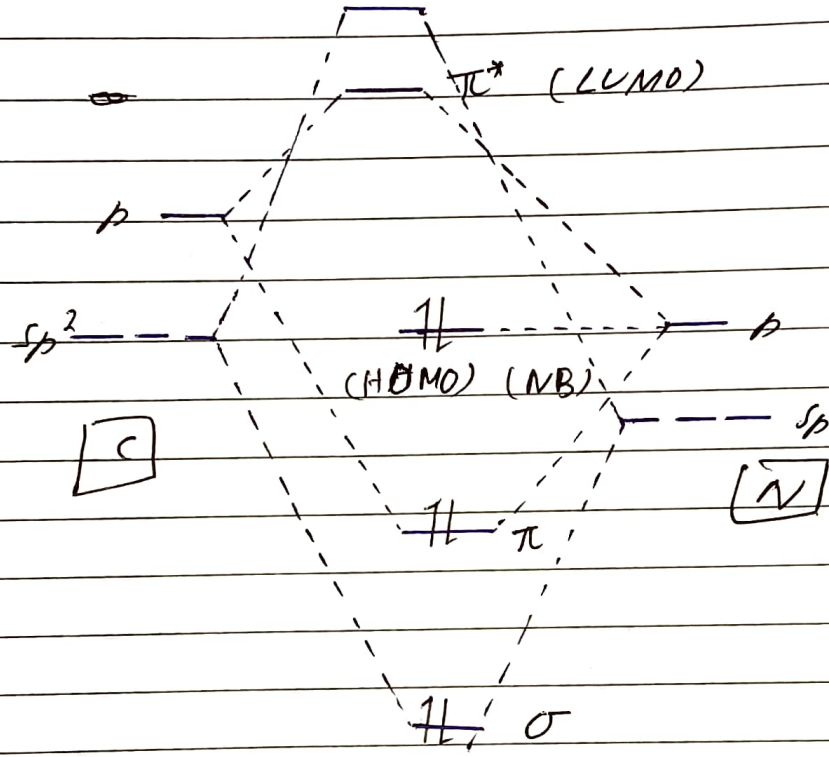
(c) 

F.C = −1



F.C. = −1

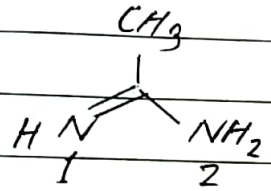
4.



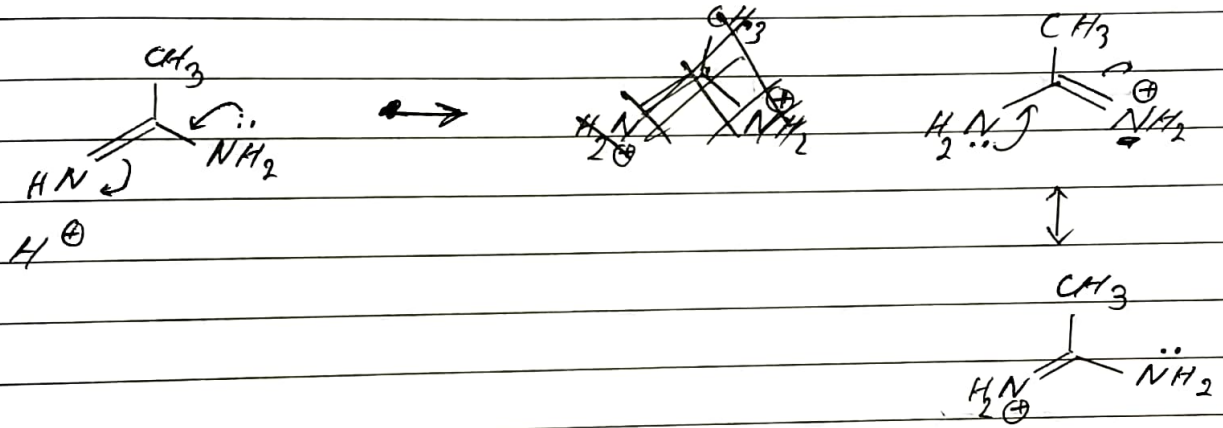
The HOMO is the non-bonding MO (2p) on N. They are the most easily donated to proton.

The LUMO is the π* which has more contribution from C. So H_3O attacks C.

(5)



N1 and N2 are both sp^2 hybridized since this is a planar molecule.



The protonation will take place at N1 since lp on N2 is delocalized. Resonance further increases e⁻ density on N1.