1 For each of the following species
(i) draw a Lewis structure, writing non-zero formal charges on the atoms that require them
(ii) indicate the hybridization state of all atoms other than hydrogen
(iii) characterize the shape of the molecule using the terms *linear, bent, planar, tetrahedral* or *pyramidal*
(iv) if appropriate, draw a resonance structure of the molecule

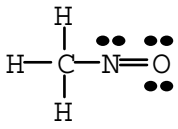
a NO_2^+ (N is the central atom)

b BH_3 (B is the central atom)

c N_3^- (three N atoms in a row)

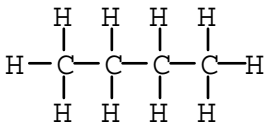
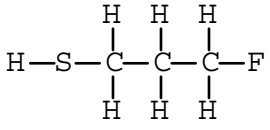
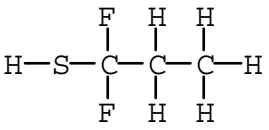
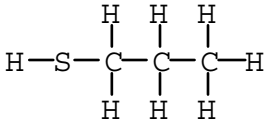
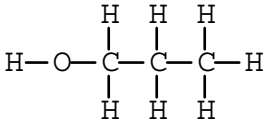
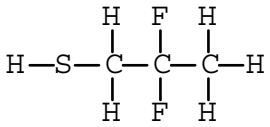
d CH_2NH (two H's bonded to C, C bonded to N, one H bonded to N)

2 (i) Draw a three-dimensionally accurate picture of the molecular orbitals in nitrosomethane; (ii) label each molecular orbital as a sigma (σ), pi (π) or non-bonding (n) orbital.



nitrosomethane

3 Rank these compounds in order of acidity (1 = most acidic).

4 Given the pK_as in the table at right, (i) complete the following acid–base reactions; (ii) indicate whether the equilibrium lies to the left or to the right.

Acid	**pK_a***
HCl	–7
CH_3S***H***	10
HO***H***	16
$(CH_3)_3CO$***H***	19
$(CH_3)_3CC{\equiv}C$***H***	25
$(CH_3)_2N$***H***	35
H_3C***H***	50

* pK_as refer to the proton ***in bold type***.

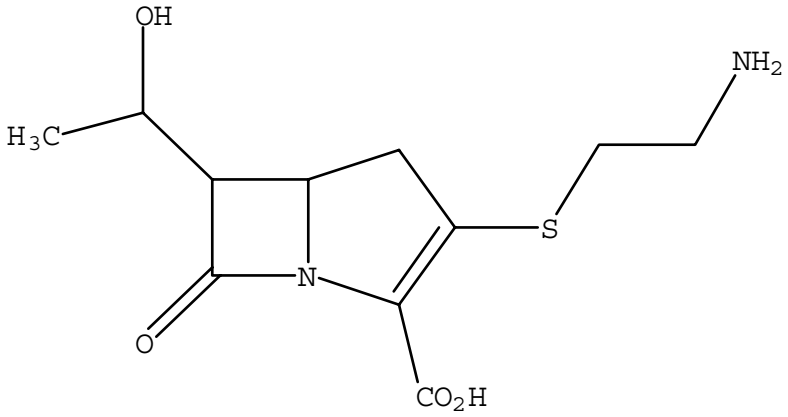
a $CH_3SH + OH^- \rightarrow$

b $(CH_3)_3CC{\equiv}CH + (CH_3)_2N^- \rightarrow$

c $(CH_3)_3CC{\equiv}CH + (CH_3)_3CO^- \rightarrow$

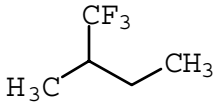
d $HCl + CH_3^- \rightarrow$

5 Circle and identify the functional groups in the antibiotic thienamycin (shown below).

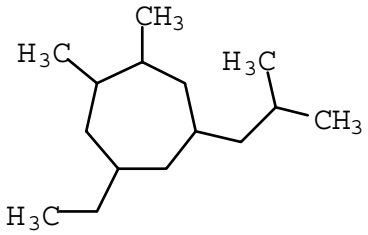


6 Name these compounds.

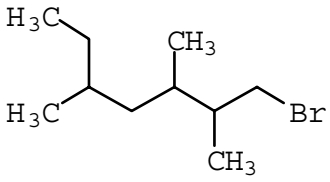
a



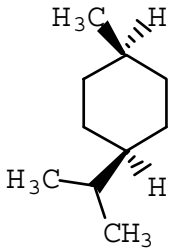
b



c



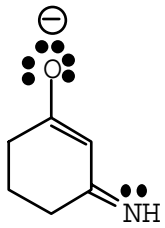
d

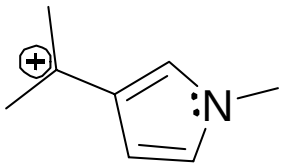


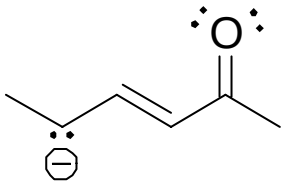
7 Draw in Newman projection (i) the most stable conformation of 2,2,3-trimethylbutane with respect to rotation about the C2–C3 bond, (ii) the least stable conformation of 2,2,3-trimethylbutane with respect to rotation about the C2–C3 bond, and (iii) calculate the strain energy of each conformation using the values in the table.

Interaction	**Strain energy** [kcal/mol]
H,H eclipse	1.0
CH_3,H eclipse	1.4
CH_3,CH_3 eclipse	2.6
CH_3,CH_3 *gauche*	0.9
CH_3,H 1,3-diaxial	0.9

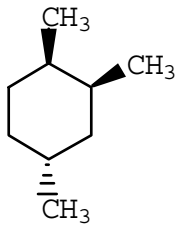
8 Draw two additional, reasonable resonance structures of the ions shown below; indicate the movement of electron pairs using the curved-arrow convention.







9 Draw both chair conformations of (1*R*,2*S*,4*R*)-1,2,4-trimethylcyclohexane and calculate the strain energy of each chair. Use the values in the table in Question 7.



(1*R*,2*S*,4*R*)-1,2,4-trimethylcyclohexane

Interaction	**Strain energy** [kcal/mol]
H,H eclipse	1.0
CH_3,H eclipse	1.4
CH_3,CH_3 eclipse	2.6
CH_3,CH_3 *gauche*	0.9
CH_3,H 1,3-diaxial	0.9