1. I

Sodium hydroxide neutralises acid.

$$H^+ + OH^- \rightarrow H_2O$$

In a 11 000 dm^3 sample of an aqueous solution, the concentration of acid, $[H^+]$, is 1.26×10^{-3} mol dm^{-3}.

Which mass of solid sodium hydroxide neutralises the acid?

A 0.0214 g **B** 0.0504 g **C** 236 g **D** 554 g

Ans: D

mol = $11000 \times 1.26 \times 10^{-3}$

mass = $(11000 \times 1.26 \times 10^{-3})(23+16+1) = 554.4$

2.

Which statement describes the bond between carbon and hydrogen in an ethene molecule?

A a π bond between an s orbital and an sp^2 orbital

B a π bond between an s orbital and an sp^3 orbital

C a σ bond between an s orbital and an sp^2 orbital

D a σ bond between an s orbital and an sp^3 orbital

Ans: C

3.

The double bond between the two carbon atoms in an ethene molecule consists of one σ bond and one π bond.

Which orbitals overlap to form each of these bonds?

	σ bond	π bond
A	sp^2–sp^2	p–p
B	sp^2–sp^2	sp^2–sp^2
C	sp^3–sp^3	p–p
D	sp^3–sp^3	sp^2–sp^2

Ans: A

4.

Phosphorus forms a compound with hydrogen called phosphine, PH_3. This compound can react with a hydrogen ion, H^+.

Which type of interaction occurs between PH_3 and H^+?

A dative covalent bond

B dipole-dipole forces

C hydrogen bond

D ionic bond

Ans: A

5.

When ammonia, NH_3, is dissolved in water, a small concentration of ammonium ions, NH_4^+, is formed.

Which row is correct?

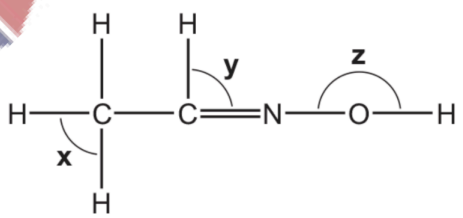
	number of electrons in one ammonium ion	change of the H–N–H angle from ammonia to the ammonium ion
A	8	decreases
B	8	increases
C	10	decreases
D	10	increases

Ans: D

- NH3 has bond angle of 107 due to pyramidal shape due to lp; NH4+ has bond angle of 109.5 since it is tetrahedral. Thus angle increases.
- no of electrons = no of valence e in N + no of valence e in 4H + 1 (--1 charge)
  = 5 + 4 + 1 = 10

6.

Ethanal reacts with hydroxylamine, NH_2OH, to form the molecule shown.



What is the order of **increasing** bond angle in this structure from smallest to largest?

A z, x, y **B** y, z, x **C** x, z, y **D** z, y, x

Ans: A

- x = 109.5 (sp3 = tetrahedral)
- y = 120 (sp2)
- z = 104.5 (bent)

7.

Atom X is the central atom in a molecule.

In this molecule, atom X has four pairs of valence electrons in its outer shell.

The four pairs of valence electrons include at least one bond pair and at least one lone pair.

What could be a possible shape for the molecule?

A linear

B non-linear

C trigonal bipyramidal

D trigonal planar

Ans: B

8.

A stable ion N_5^+ has been produced by research chemists.

Which structure is most likely to show the electron arrangement of this ion?

A

B

C

D

Ans: C

9.

At 200 °C aluminium chloride is a gas with M_r = 267.

What is the number of covalent bonds, dative covalent bonds and lone pairs of electrons in one molecule of aluminium chloride at 200 °C?

	covalent bonds	dative covalent bonds	lone pairs
A	6	2	0
B	6	2	16
C	6	2	18
D	3	0	9

Ans: B

10.

The eight species that follow all have covalent bonds.

In which pair do the species have different shapes from each other?

A $BeCl_2$ and CO_2

B CH_4 and NH_4^+

C NH_3 and BF_3

D SCl_2 and H_2O

Ans: C

11.

In which species is there a lone pair of electrons?

A CH_3 **B** CH_3^+ **C** CH_3^- **D** CH_4

Ans: C

12.

Which molecule or ion contains the smallest bond angle?

A C_2H_4 **B** CH_3COCH_3 **C** NH_4^+ **D** NH_3

Ans: D

13.

In which set do all the molecules have all their atoms arranged in one plane?

A $AlCl_3$, BF_3, PH_3

B $AlCl_3$, CO_2, NH_3

C BF_3, C_2H_4, C_3H_6

D C_2H_4, CO_2, H_2O

Ans: D

NOTE: C3H6 is NOT planar because one of the C–C bonds is a single bond

14.

In which structure are three atoms bonded together in a straight line?

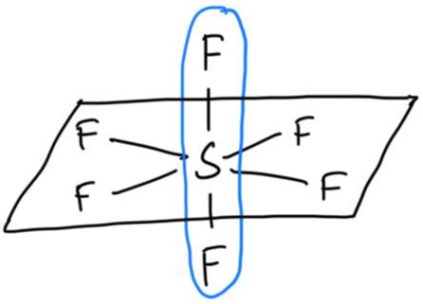
A poly(ethene), $-(CH_2CH_2)_n-$

B propane, C_3H_8

C silicon tetrachloride, $SiCl_4$

D sulfur hexafluoride, SF_6

Ans: D



- In polyethene, there are n number of CH2 units linked together; each C atom is the centre of a tetrahedral arrangement.
- In C3H8 and SiCl4, tetrahedral

15.

Which series shows molecules in order of increasing bond angle?

A $CH_4 \rightarrow BF_3 \rightarrow NH_3$

B $H_2O \rightarrow CO_2 \rightarrow BF_3$

C $NH_3 \rightarrow CH_4 \rightarrow CO_2$

D $NH_3 \rightarrow CH_4 \rightarrow H_2O$

Ans: C

16.

Which row of the table is correct?

	shape		bonds present	
	ammonia molecule	ammonium ion	ammonia molecule	ammonium ion
A	pyramidal	regular tetrahedral	σ	σ
B	pyramidal	regular tetrahedral	σ	π
C	regular tetrahedral	pyramidal	σ	σ
D	regular tetrahedral	pyramidal	π	σ

Ans: A

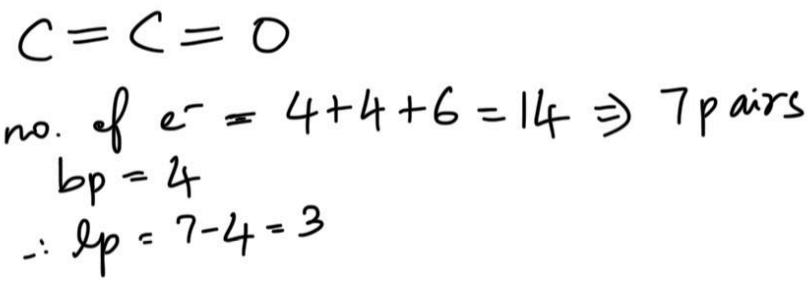
17.

Dicarbon monoxide, C_2O, is found in dust clouds in space. The structure of this molecule is C=C=O. The molecule contains no unpaired electrons.

How many lone pairs of electrons are present in a molecule of C_2O?

A 1 **B** 2 **C** 3 **D** 4

Ans: C

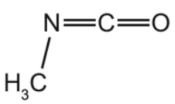


18.

Methyl isocyanate, CH_3NCO, is a toxic liquid which is used in the manufacture of some pesticides.

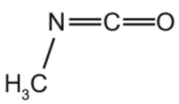
What is the approximate angle between the bonds formed by the N atom in a molecule of methyl isocyanate?

A



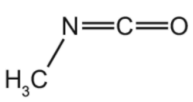
104°

B



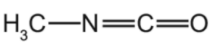
109°

C



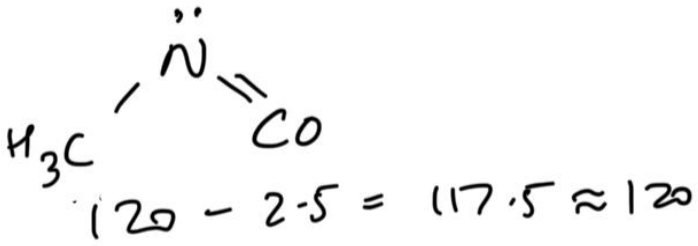
120°

D



180°

Ans: C



19.

The strength of hydrogen bonding increases as the electronegativity of the element bonded to hydrogen increases.

Some information for a range of hydrides is given.

hydride	boiling point / K
PH_3	185
HCl	188
HF	293
H_2O	373

Which statement and reason about these hydrides is correct?

A The boiling point of PH_3 is much lower than the boiling point of H_2O because PH_3 does not form hydrogen bonds or instantaneous dipole-induced dipole forces between its molecules.

B The boiling point of HF is higher than the boiling point of HCl because the bond energy of H–F is greater than the bond energy of H–Cl.

C The boiling point of H_2O is higher than the boiling point of HF because each hydrogen bond between the H_2O molecules is stronger than each hydrogen bond between HF molecules.

D The boiling points of PH_3 and HCl are similar because the molecules of PH_3 and HCl have the same number of electrons and similar intermolecular forces.

Ans: D

In C, each H bond between HF > H2O, but H2O is more extensively H bonded.

20.

Which type of interaction exists between water molecules and metal cations in aqueous solution?

A dipole-dipole interactions

B hydrogen bonds

C ion-dipole interactions

D ionic bonds

Ans: C

21.

In which change are **only** temporary dipole-induced dipole forces overcome?

A $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$

B $H_2O(s) \rightarrow H_2O(l)$

C $O_2(s) \rightarrow O_2(l)$

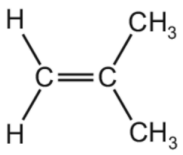
D $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$

Ans: C

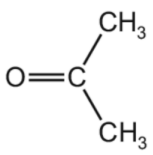
22.

Which molecule has the largest overall dipole?

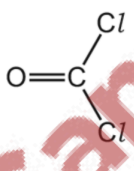
A



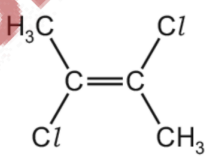
B



C



D



Ans: B

23.

Which organic compound has the highest boiling point?

A $C(CH_3)_4$

B $CH_3CH_2CH_2CH_2CH_3$

C $CH_3COCH_2CH_3$

D $CH_3CH(OH)CH_2CH_3$

Ans: D
D has OH group, thus H bonding

NOTE:
Si–Si bond is weaker than C–C bond because silicon atoms have a larger atomic radius that carbon atoms; this talks about the covalent bonds between atoms NOT intermolecular id–id forces, which increase with increasing number of electrons.

24.

Which quantity gives the best indication of the relative strengths of the hydrogen bonds between the molecules in liquid hydrogen halides?

A bond dissociation energies

B enthalpy changes of formation

C enthalpy changes of solution

D enthalpy changes of vaporisation

Ans: D

NOTE: alcohols & carboxylic acids have hydrogen bonding; ketones and aldehydes do not have hydrogen bonding.

NOTE: CO is polar; CO_2 is non–polar.

25.

Which type of bonding is **never** found in elements?

A covalent

B ionic

C metallic

D van der Waals' forces

Ans: B

- Covalent = found in O, H, N, etc.
- Ionic = only found in salts & ionic compounds
- Metallic = all metals
- Van der Waals' forces = in noble gases, diatomic gases, etc.

26.

In the sodium chloride lattice the number of chloride ions that surround each sodium ion is called the coordination number of the sodium ions.

What are the coordination numbers of the sodium ions and the chloride ions in the sodium chloride lattice?

	coordination number of sodium ions	coordination number of chloride ions
A	4	6
B	6	4
C	6	6
D	8	6

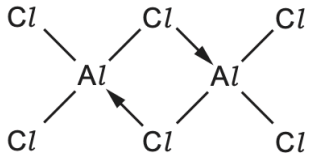
Ans: C

27.

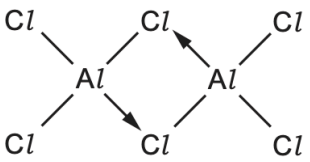
Solid aluminium chloride sublimes at 178 °C.

Which structure best represents the species in the vapour at this temperature?

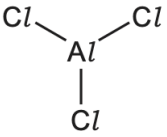
A



B



C



D

$Al^{3+}(Cl^{-})_3$

Ans: A

28.

Which row about silicon, Si, and magnesium, Mg, and their ions is correct?

	comparison of silicon and magnesium	explanation
A	Si has a greater atomic radius than Mg.	Si has electrons in 3p orbitals. Mg has electrons in the 3s orbital only.
B	Si has a lower electrical conductivity than Mg.	Si has 4 delocalised electrons per atom. Mg only has 2 delocalised electrons per atom.
C	Si has a lower melting point than Mg.	Si has covalent bonding. Mg has metallic bonding.
D	The radius of Si^{4+} is smaller than the radius of Mg^{2+}.	Si has a greater nuclear charge than Mg.

Ans: D

29.

For which molecule is the dipole moment zero?

A CH_3Cl **B** CH_2Cl_2 **C** $CHCl_3$ **D** CCl_4

Ans: D

30.

When ammonia, NH_3, is dissolved in water, a small concentration of ammonium ions, NH_4^+, is formed.

Which row is correct?

	number of electrons in one ammonium ion	change of the H–N–H angle from ammonia to the ammonium ion
A	8	decreases
B	8	increases
C	10	decreases
D	10	increases

Ans: D

31.

HCN has been detected in interstellar gas. The molecules below have also been detected in interstellar gas.

Which molecule contains the same total number of valence shell (outer shell) electrons as HCN?

A HNO **B** NH_3 **C** NO **D** PN

Ans: D

32.

A stable ion N_5^+ has been produced by research chemists.

Which structure is most likely to show the electron arrangement of this ion?

A

B

C

D

Ans: C

33.

Which row is correct?

	shape of H_3O^+	shape of SCl_2
A	pyramidal	non-linear
B	pyramidal	linear
C	trigonal planar	non-linear
D	trigonal planar	linear

Ans: A

34.

Ammonium ions, NH_4^+, are formed when ammonia gas reacts with hydrogen chloride gas.

Which statement about the changes that occur in this reaction is correct?

A The dipole moment of an ammonium ion is greater than the dipole moment of an ammonia molecule.

B The H–N–H bond angle decreases when an ammonium ion is formed.

C The hybridisation of nitrogen does **not** change.

D There is electron transfer from nitrogen to chlorine.

Ans: C

35.

Two compounds of boron are sodium borohydride, $NaBH_4$, and boron trifluoride, BF_3.

What are the shapes of the borohydride ion and the boron trifluoride molecule?

	borohydride ion	boron trifluoride
A	square planar	pyramidal
B	square planar	trigonal planar
C	tetrahedral	pyramidal
D	tetrahedral	trigonal planar

Ans: D

36.

Aluminium chloride exists as Al_2Cl_6 molecules at room temperature. When heated to a high temperature, $AlCl_3$ molecules are formed.

What are the arrangements of the bonding pairs of electrons around the aluminium atom in the two forms of aluminium chloride?

	$AlCl_3$	Al_2Cl_6
A	planar	planar
B	planar	tetrahedral
C	tetrahedral	tetrahedral
D	tetrahedral	octahedral

Ans: B

37.

In which species is there a lone pair of electrons?

A CH_3 **B** CH_3^+ **C** CH_3^- **D** CH_4

Ans: C

- CH3 has a lone electron, NOT a lone pair of electrons