Chemical bonding – 2021 AS

1. Nov/2021/Paper_11/No.5

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

2. Nov/2021/Paper_11/No.6

Which substance shows the greatest deviation from the properties of an ideal gas under room conditions?

A $CO_2(g)$ **B** $H_2(g)$ **C** Ne(g) **D** $NH_3(g)$

3. Nov/2021/Paper_11/No.18

Which row 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

4. Nov/2021/Paper_11/No.19

The table describes two possible environmental consequences of adding too much ammonium nitrate fertiliser to the soil.

Which row is correct?

	increased plant growth in rivers	photochemical smog
A	✗	✗
B	✓	✗
C	✗	✓
D	✓	✓

5. Nov/2021/Paper_11/No.34

Which molecules contain at least one unpaired electron?

1 NO

2 NO_2

3 NH_3

6. Nov/2021/Paper_11/No.35

Which elements form a chloride in which both covalent bonding and coordinate (dative covalent) bonding are present?

1 Al

2 Si

3 Mg

7. Nov/2021/Paper_12/No.5

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

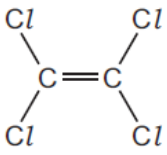
C trigonal bipyramidal

D trigonal planar

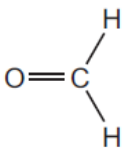
8. Nov/2021/Paper_12/No.6

Which molecule has the largest overall dipole?

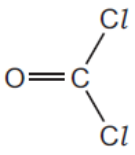
A



B



C



D

9. Nov/2021/Paper_12/No.7

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.

10. Nov/2021/Paper_12/No.35

The following statements compare some properties of the oxides and chlorides of sodium and silicon.

Which statements are correct?

1 The melting point of $SiCl_4$ is higher than the melting point of SiO_2.

2 $SiCl_4$ reacts with water, $NaCl$ does not.

3 The melting point of $SiCl_4$ is lower than the melting point of $NaCl$.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

11. Nov/2021/Paper_13/No.18

Which row 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

12. Nov/2021/Paper_13/No.35

Which elements form a chloride in which both covalent bonding and coordinate (dative covalent) bonding are present?

1 Al

2 Si

3 Mg

13. March/2021/Paper_12/No/.12

Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

A No visible change is observed.

B Steamy fumes and a precipitate are both observed.

C The appearance of a precipitate is the only observation.

D The appearance of steamy fumes is the only observation.

14. March/2021/Paper_12/No/.34

Which species can accept a lone pair of electrons to form a coordinate (dative covalent) bond?

1 BF_3

2 H^+

3 CH_3^+

15. June/2021/Paper_11/No.3

Phosphorus forms two chlorides. Phosphorus(III) chloride, PCl_3, is a covalent liquid.

Phosphorus(V) chloride is an ionic solid. One of the ions present is $[PCl_4]^+$.

What is the shape of the PCl_3 molecule and the $[PCl_4]^+$ ion?

	PCl_3	$[PCl_4]^+$
A	pyramidal	square planar
B	pyramidal	tetrahedral
C	tetrahedral	square planar
D	trigonal planar	tetrahedral

16. June/2021/Paper_11/No.34

Which molecules contain at least one bond angle of 120°?

1 C_2H_4

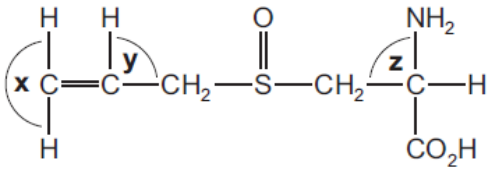
2 PF_5

3 NCl_3

17. June/2021/Paper_12/No.4

The structural formula of alliin is shown.

alliin

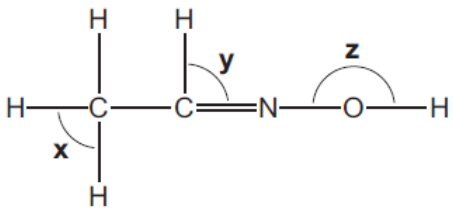


What are the approximate bond angles **x**, **y** and **z** in a molecule of alliin?

	x	**y**	**z**
A	90°	90°	109°
B	120°	109°	90°
C	120°	120°	109°
D	180°	109°	109°

18. June/2021/Paper_13/No.4

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

19. June/2021/Paper_13/No.5

Descriptions of the bonding in three substances are given.

substance 1	strong covalent bonds between atoms, permanent dipole-dipole attractions between molecules
substance 2	strong covalent bonds between atoms, weak forces between molecules
substance 3	strong covalent bonds between atoms, hydrogen bonding between molecules

Which compounds could be substances 1, 2 and 3?

	substance 1	substance 2	substance 3
A	CH_3OH	Al_2Cl_6	CH_2Cl_2
B	Al_2Cl_6	CH_2Cl_2	CH_4
C	CH_2Cl_2	CH_4	CH_3OH
D	CH_4	CH_3OH	H_2O

20. June/2021/Paper_13/No.6

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

A covalent

B ionic

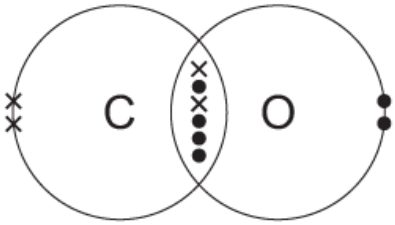
C metallic

D van der Waals' forces

21. June/2021/Paper_21/No.2

Carbon monoxide gas, CO(g), and nitrogen gas, $N_2(g)$, are both diatomic molecules.

(a) The diagram shows the arrangement of outer electrons in a molecule of CO(g).



(i) State **one** similarity and **one** difference in the way the atoms in a carbon monoxide molecule are bonded together compared to the atoms in a nitrogen molecule.

.....

.....

..... [2]

(ii) The table states the electronegativity values of carbon, nitrogen and oxygen atoms.

	C	N	O
electronegativity	2.5	3.0	3.5

Use the electronegativity values and relevant details from the *Data Booklet* to complete the table below.

	N_2	CO
number of electrons per molecule		
type(s) of intermolecular (van der Waals') force		

[2]

(b) $N_2(g)$ is less reactive than CO(g) even though $N_2(g)$ has a lower bond energy than CO(g).

Suggest why CO(g) is more reactive than $N_2(g)$.

.....

..... [1]

(c) Both carbon monoxide and nitrogen are gases at room temperature and pressure.

They both behave like ideal gases under certain conditions.

(i) State the **two** conditions necessary for these two gases to approach ideal gas behaviour.

.....

..... [1]

(ii) Explain why $N_2(g)$ behaves more like an ideal gas than CO(g) does at 20.0 °C and 101 kPa.

.....

.....

..... [2]

(d) Calculate the amount, in mol, of pure nitrogen gas which occupies 100 cm^3 at 101 kPa and 20.0 °C.

Use relevant information from the *Data Booklet*. Show your working.

Assume nitrogen behaves as an ideal gas.

..... mol
[3]

[Total: 11]

22. June/2021/Paper_22/No.2

The strength of interaction between particles determines whether the substance is a solid, liquid or gas at room temperature.

(a) Lithium sulfide, Li_2S, is a crystalline solid with a melting point of 938 °C. It conducts electricity when it is molten.

(i) Give the formulae of the particles present in solid lithium sulfide.

..... [1]

(ii) Explain, in terms of the structure of the crystalline solid, why lithium sulfide has a high melting point.

.....

..... [2]

(b) Carbon monoxide, CO, is a gas at room temperature and pressure. It contains a coordinate bond.

(i) Explain what is meant by *coordinate bond*.

.....

..... [1]

(ii) Draw a 'dot-and-cross' diagram to show the arrangement of outer electrons in CO.

Show the electrons belonging to the C atom as ×.

Show the electrons belonging to the O atom as ●.

[2]

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(c) Nitrogen, N_2, is also a gas at room temperature and pressure. Neither CO nor N_2 is an ideal gas.

(i) State two assumptions that are made about the behaviour of particles in an ideal gas.

1 .....

.....

2 .....

.....

[2]

(ii) Explain why N_2 does not behave as an ideal gas at very high pressures.

.....

.....

.....

..... [2]

(iii) Complete the table by naming **all** the types of intermolecular forces (van der Waals') in separate samples of $N_2(g)$ and CO(g).

	$N_2(g)$	CO(g)
number of electrons per molecule	14	14
presence of a dipole moment	✗	✓
boiling point/°C	–195.8	–191.5
intermolecular forces (van der Waals')		

[2]

(iv) Suggest why the bond in a molecule of CO contains a dipole moment.

..... [1]

[Total: 13]

23. June/2021/Paper_23/No.2

Methanol, CH_3OH, is soluble in water because it forms hydrogen bonds with water molecules.

(a) Draw a fully labelled diagram to show how a hydrogen bond forms between a water molecule and a methanol molecule.

[3]

(b) Methanol has a melting point of –97.6 °C and a boiling point of 64.7 °C.

A sample of pure liquid methanol is added to a flask and then sealed. The sealed flask is left for several days at constant temperature. The vapour pressure is then measured as 17 kPa.

(i) Describe what is meant by the term *vapour pressure of methanol*.

.....

.....

..... [2]

(ii) Explain why some of the liquid becomes a vapour.

.....

.....

..... [1]

(iii) Suggest and explain why the vapour pressure of water at room temperature is lower than the vapour pressure of methanol at room temperature. Refer to the correct intermolecular forces in your answer.

.....

.....

..... [2]

(c) Methanol is made by reacting carbon monoxide with hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

Carbon monoxide and hydrogen react at 1.0×10^7 Pa and 200 °C. Eventually the reaction mixture reaches dynamic equilibrium.

The table shows the amounts of each species present in the mixture.

	CO(g)	$H_2(g)$	$CH_3OH(g)$
initial amount / mol	1.0	2.0	0
equilibrium amount / mol	0.030	0.060	0.97

(i) Explain what is meant by *dynamic equilibrium*.

.....

.....

..... [2]

(ii) Calculate the partial pressure of methanol vapour at equilibrium under these conditions. Show your working.

..... Pa [2]

(iii) Write an expression for the equilibrium constant, K_p, for this reaction. State the units in your answer.

K_p =

units = ... [2]

[Total: 14]