

States of matter – 2021 AS

1. 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 ₂ O	373

Which statement and reason about these hydrides is correct?

- A The boiling point of PH₃ is much lower than the boiling point of H₂O because PH₃ 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 H₂O is higher than the boiling point of HF because each hydrogen bond between the H₂O molecules is stronger than each hydrogen bond between HF molecules.
- D The boiling points of PH₃ and HCl are similar because the molecules of PH₃ and HCl have the same number of electrons and similar intermolecular forces.

2. Nov/2021/Paper_12/No.8

The general gas equation can be used to calculate the value of the M_r of a gas.

For a sample of a gas of mass m grams, which expression will give the value of M_r ?

- A $M_r = \frac{mRT}{pV}$ B $M_r = \frac{pVRT}{m}$ C $M_r = \frac{mpV}{RT}$ D $M_r = \frac{pV}{mRT}$

3. Nov/2021/Paper_13/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

4. **Nov/2021/Paper_13/No.6**

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

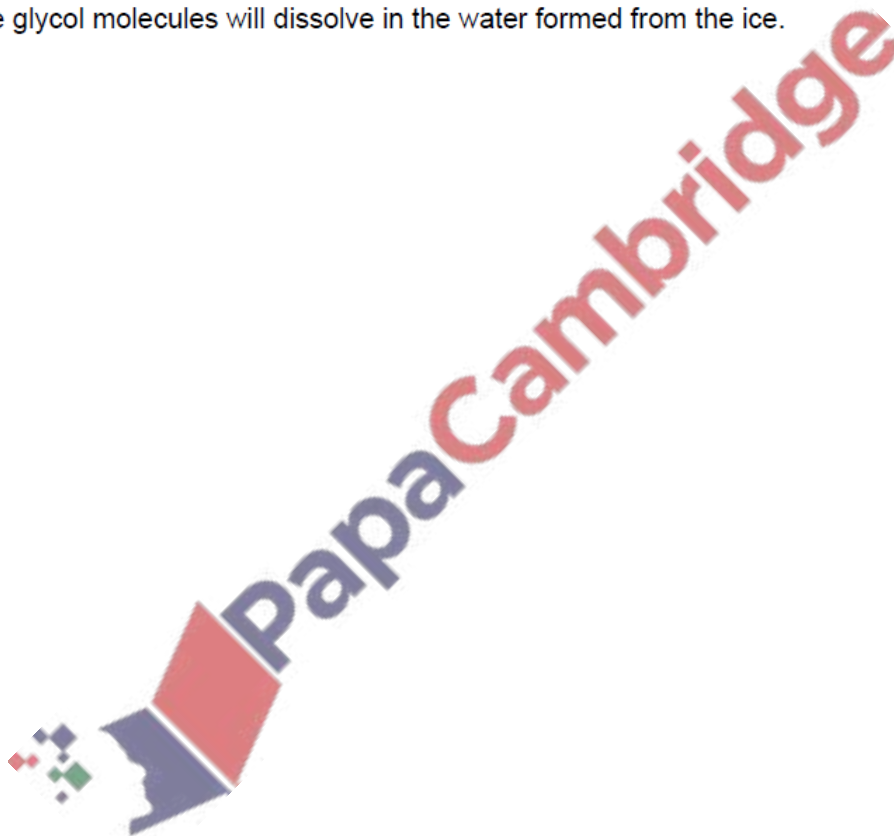
- A $\text{CO}_2(\text{g})$ B $\text{H}_2(\text{g})$ C $\text{Ne}(\text{g})$ D $\text{NH}_3(\text{g})$

5. **Nov/2021/Paper_13/No.33**

Ethylene glycol, $\text{HOCH}_2\text{CH}_2\text{OH}$, is used as a de-icer. It allows ice to melt at temperatures below 0°C .

Which statements are correct?

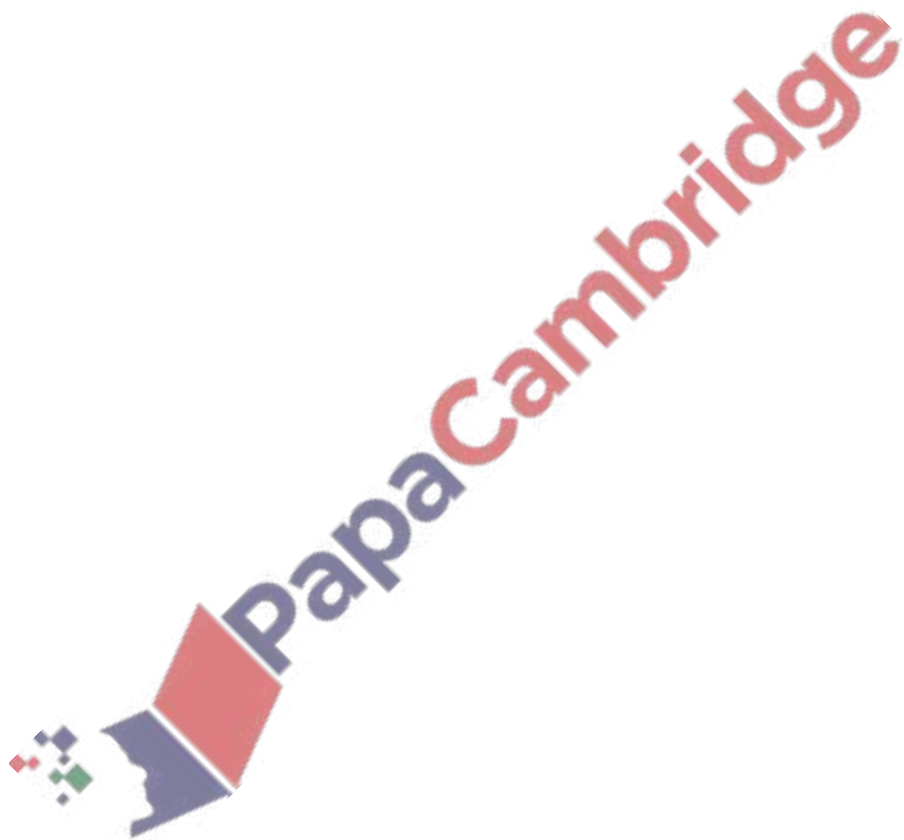
- 1 Ethylene glycol disrupts the extensive network of hydrogen bonds in ice.
- 2 Ethylene glycol molecules form hydrogen bonds with other ethylene glycol molecules.
- 3 Ethylene glycol molecules will dissolve in the water formed from the ice.



6. **March/2021/Paper_12/No/.5**

In which substance are the only intermolecular forces temporary dipole-induced dipole attractions?

- A hydrogen chloride
- B methanol
- C octane
- D water



7. June/2021/Paper_11/No.8

Which gas would behave most like an ideal gas under room conditions?

- A helium
- B nitrogen
- C ammonia
- D krypton

8. June/2021/Paper_12/No.5

Flask Q contains 5 dm^3 of helium at 12 kPa pressure. Flask R contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

- A 8 kPa B 9 kPa C 10 kPa D 11 kPa

9. June/2021/Paper_12/No.6

Sodium chloride, water and air represent three states of matter – solid, liquid and gas.

Which row is correct?

	sodium chloride	water	air
A	particles held in rigid structure	can easily be compressed	can easily be compressed
B	particles stationary	particles move	cannot easily be compressed
C	particles stationary	particles stationary	particles move
D	resistant to change of shape	cannot easily be compressed	can easily be compressed

10. June/2021/Paper_13/No.24

A mixture of ethanol and methanol is burned in oxygen to produce 35 cm^3 of CO_2 and 55 cm^3 of H_2O .

Complete combustion occurs and the volumes of both products are measured at 101 kPa and 120°C .

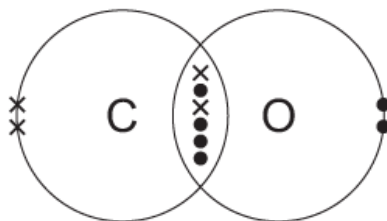
What is the molar ratio, ethanol : methanol, in the mixture?

- A 1:3 B 2:3 C 3:2 D 3:1

11. June/2021/Paper_21/No.2

Carbon monoxide gas, CO(g), and nitrogen gas, N₂(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.

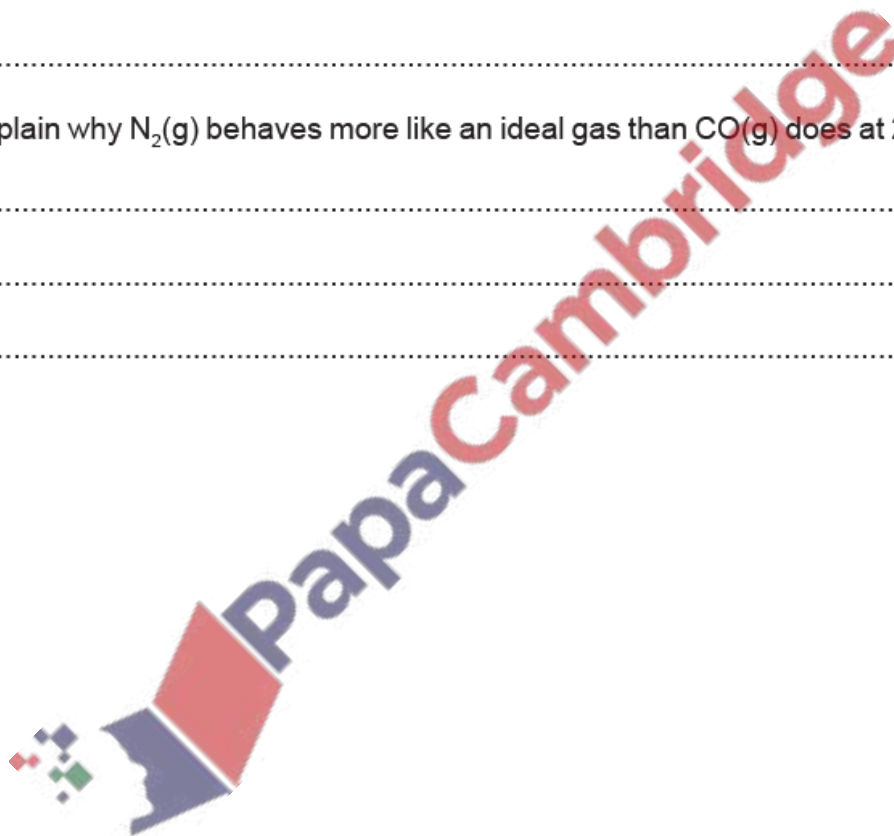
They both behave like ideal gases under certain conditions.

(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 $20.0^\circ C$ and 101 kPa .

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..... [2]



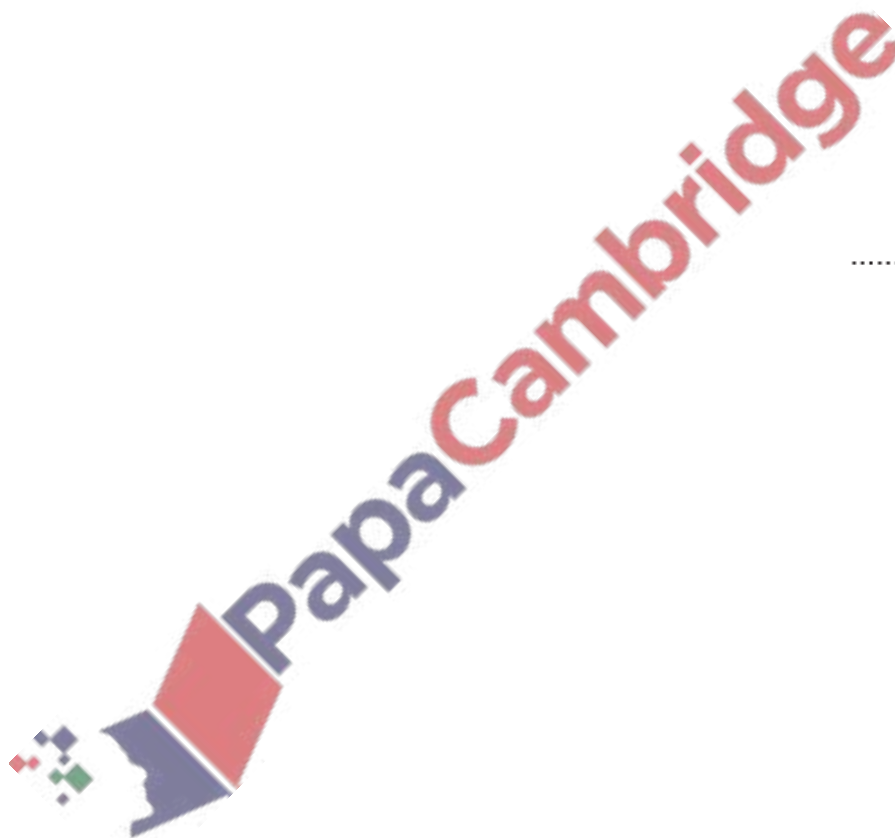
(d) Calculate the amount, in mol, of pure nitrogen gas which occupies 100 cm^3 at 101 kPa and 20.0°C .

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

Assume nitrogen behaves as an ideal gas.

..... mol
[3]

[Total: 11]



12. 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.

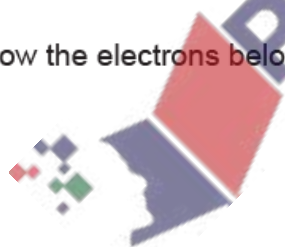
(i) Explain what is meant by *coordinate bond*.

.....
..... [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 x.

Show the electrons belonging to the O atom as •.



[2]

(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.

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..... [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	x	✓
boiling point/ $^{\circ}C$	-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]