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_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.

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

5. Nov/2021/Paper_13/No.33

Ethylene glycol, $HOCH_2CH_2OH$, 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.

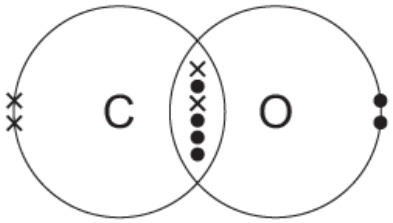
What is the molar ratio, ethanol : methanol, in the mixture?

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, $N_2(g)$, 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]

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(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 ×.

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]