2024 H2 Chemistry Y5 Timed Practice – Suggested Solutions

Section A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	C	B	D	B	A	B	A	B	D	D	D	C	D	C

1 **Answer: C**

Amt of atoms in 0.2 g O_2 = 0.2 / 32.0 x 2 = **0.0125 mol**

Amt of atoms in 0.225 g H_2O = 0.225 / 18.0 x 3 = 0.0375 mol
Amt of ions in 1.275 g of Al_2O_3 = 1.275 / 102 x 5 = 0.0625 mol
Amt of atoms in 0.300 dm^3 of Ne at r.t.p. = 0.300 / 24 x 1 = **0.0125 mol**
Amt of atoms in 0.284 dm^3 of N_2 at s.t.p. = 0.284 / 22.7 x 2 = 0.0250 mol

2 **Answer: C**

amt of e^- transferred = 2 x amt of Sn^{2+} reacted
= 2 x (31.20 / 1000 x 0.0400)
= 2.496×10^{-3} mol

amt of IO_3^- reacted = 25.0 / 1000 x 0.0250
= 6.25×10^{-4} mol

mol ratio of e^- : IO_3^-
= 2.496×10^{-3} : 6.25×10^{-4}
= 3.99 : 1
≈ 4 : 1 (i.e. 1 mol of IO_3^- gains 4 moles of e^-.)

oxidation number of I in product = (+5) – 4
= **+1**

3 **Answer: B**

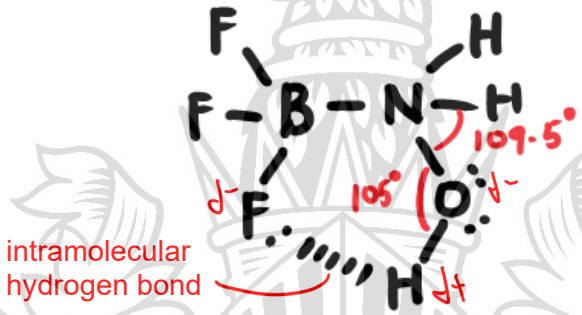
There is a large decrease in the 5th IE from R to S
⇒ R^{4+} has a noble gas configuration after losing 4 electrons.
⇒ R is in Group 14.
⇒ Q is in Group 13.

The chloride is **QCl_3**.

4 **Answer: D**

The angle of deflection is proportional to charge to mass ratio.
For $^7Li^+$, charge / mass = +1/7 and angle = $+x^o$ (towards +ve terminal)

Option A: charge / mass = –2/14 = –1/7, so angle = $-x^o$ (towards –ve terminal)
Option B: charge / mass = –1/16, so angle < $-x^o$ (towards –ve terminal)
Option C: charge / mass = +3/27 = +1/9, so angle < $+x^o$ (towards +ve terminal)
Option D: charge / mass = +7/35 = +1/5, so **angle > $+x^o$ (towards +ve terminal)**

5	**Answer: B** BrF_2^+ is bent with a bond angle of about 105°. NO_2 is bent with a bond angle greater than 120°. XeF_2 is linear with a bond angle of 180°. Hence bond angle of **BrF_2^+ < NO_2 < XeF_2**.
6	**Answer: A** Statement 1 is correct as there is an intramolecular hydrogen bond between one of the F atoms and the H atom of the –OH group.  Statement 2 is correct as there are 4 bond pairs (3 single bonds and 1 dative bond) around B atom and so the bonds around B are tetrahedrally arranged. Statement 3 is correct as there are 4 bond pairs around N atom but 2 bond pairs and 2 lone pairs around O atom, causing the H–N–O angle to be 109.5° and the H–O–N angle to be 105°. This is because the lone pair exerts greater repulsion than the bond pair.
7	**Answer: B** Option **1** Si, AlF_3, HCl are **giant molecular, ionic, simple molecular** respectively. Option 2 $SiCl_4$, Al_2O_3, HBr are simple molecular, ionic, simple molecular respectively. Option **3** $AlCl_3$, SiO_2, BaI_2 are **simple molecular, giant molecular, ionic** respectively.
8	**Answer: A** • and ○ represent Na^+ and Cl^- respectively. (Note: Na^+ is smaller than Cl^- in size.) Only in structure **A**, all Na^+ and Cl^- are bonded to oppositely charged ions.
9	**Answer: B** At constant V and T, p is directly proportional to n. After gas **Z** is introduced, the total pressure increases by P atm (since the final is 2P atm). ⇒ **Z** has the same number of moles as the combined amounts of **X** and **Y**. i.e. mol ratio of **X** : **Y** : **Z** = 1 : 2 : 3 new partial pressure of **X** = [1 / (1 + 2 + 3)] x 2P = **P/3 atm**
10	**Answer: D** Statement A is incorrect, increasing pressure causes boiling point to increase, not decrease. Statement B is incorrect, kinetic energy is dependent on temperature, not pressure. Statement C is incorrect, increasing pressure does not decrease the size of molecules.

	Statement D is correct, increasing the pressure pushes the molecules closer together and hence the intermolecular forces of attraction become significant and the gas condenses from gaseous to liquid state.
11	**Answer: D** $q = mc\Delta T$ $= (76 + 70)(1)(4.18)(70 - 25)$ $= 27460$ J $\Delta H = \frac{-q}{n}$ $n_{CaCl_2} = \frac{-q}{\Delta H}$ $= \frac{-27460}{-83000}$ $= 0.3309$ mol mass of $CaCl_2 = (0.3309) \times (40.1 + 35.5 \times 2)$ = **36.8 g**
12	**Answer: D** Lattice energy is the enthalpy change when one mole of ionic compound is formed from its constituent gaseous ions under standard conditions.
13	**Answer: C** Bonds broken: 1 C=C; 1 O–H Bonds formed: 1 C–C; 1 C–O; 1 C–H $\Delta H_r = BE(C=C) + BE(O-H) - BE(C-C) - BE(C-O) - BE(C-H)$
14	**Answer: D** $\Delta G = \Delta H - T\Delta S$ <u>To determine the sign of ΔS</u> When ΔG is more negative at a higher temperature, ΔS must be positive. **OR** 1 mol of gas + 1 mol of solid $\rightarrow$ 2 mol of gases $\Rightarrow \Delta S > 0$ because a gas has greater entropy than a solid <u>To determine the sign of ΔH</u> At a lower temperature, when "$-T\Delta S$" is a small negative value, ΔG is positive. This implies that ΔH is positive. **OR** $+78000 = \Delta H - 378\Delta S$ Since $\Delta S > 0$, $-378\Delta S < 0$. Thus, ΔH must be positive.

15	**Answer: C** 1. $\Delta S < 0$ Entropy decreases as the decrease in temperature causes the narrowing of the Maxwell-Boltzmann energy distribution of the particles. Thus there are fewer ways of arranging “energy quanta” in the cooler system. 2. $\Delta S > 0$ When a solid melts into a liquid, the order in the solid is destroyed. Particles in a liquid are more randomly arranged and more disordered than those in the solid, resulting in an increase in entropy. 3. $\Delta S > 0$ The entropy of a system increases as the number of particles in the system increases. With more particles, there are more ways to arrange the particles and more ways to distribute the energy in the system, and hence creating greater disorder in the system.

B1(a) The successive ionisation energy increases as the number of protons remains the same and hence **nuclear charge remains the same.** The **number of electrons decreases** and **shielding** experienced by the remaining outermost electrons **decreases.** Hence the electrostatic **attraction** between the nucleus and the remaining electrons **increases**, resulting in more energy required to remove each subsequent electron.

Examiner comments
- Students are required to explain the trend in successive ionisation energies in terms of nuclear charge and shielding, before concluding that the attraction between nucleus and remaining electrons increases.

B1(b) The **6th electron in element A is located in an inner electron shell** that is **nearer to the nucleus**, experiencing less shielding and is attracted more strongly by the nucleus.

Comparing to element **B**, the 6th electron of element **A** experiences **very little shielding** due to the **lack of inner shell electrons** whereas the 6th electron of element **B** experiences shielding by one inner electron shell.

Examiner comments
- From the large jump in Fig 1.1, students are required to identify that the 6th electron removed in element **A** is from the inner electron shell and hence, closer to nucleus.
- Then, students are required to explain why this large jump is more much significant than in element **B** by stating that the 6th electron in element **A** experiences almost no shielding (e.g. very close to the nucleus, no inner shell at all).
- Some students misunderstood the question and considered the jump in element **B** to be a small jump which corresponds to the removal of the 6th electron to be from a different subshell instead. The question states that there is a big jump for both elements, hence any answer involving the removal of the 6th electron from different sub-shells (e.g. s vs p) is not applicable here.

B1(c) $1s^2\ 2s^2\ 2p^3$

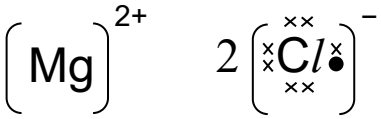
Examiner comments
- Students are reminded to indicate the number of electrons in each subshell as the *super*script (e.g. $2p^3$).

B1(d) The noble gas in the same period as element **A** (nitrogen) is neon. **Ne has a higher 1st ionisation energy** than element **A.**

Ne has a **higher nuclear charge** than element **A**. Ne also has more electrons than element **A** but this electron is added to the same outermost electron shell, and hence **shielding effect remains approximately constant.** Hence electrostatic attraction between the nucleus and the valence electrons of Ne is **stronger,** resulting in more energy required to remove the 2p electron from the Ne atom than element **A** atom.

Examiner comments
- Students are required to explain the differences between ionisation energies of elements across the Period in terms of nuclear charge and shielding.

B2(a)



Examiner comments
- In the dot-and-cross diagram, students are allowed to only use "dot" and "cross" to represent the electrons i.e. do not use any other symbols unless otherwise instructed.
- For Mg^{2+} ion, no valence electrons should be drawn. For Cl^-, the additional electron from Mg should be indicated with a different symbol from the valence electrons from Cl.
- Some drew two separate, identical dot-and-cross diagrams for Cl^- when the number "2" (as shown above) would have sufficed.
- Lastly, the charges of the ionic compound should be balanced correctly in the dot-and-cross diagram drawn.

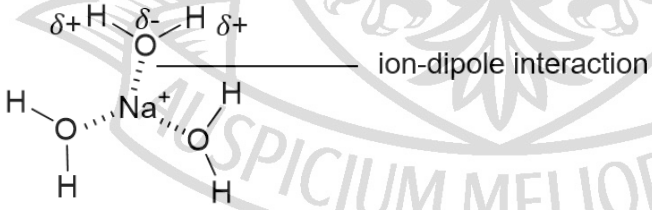
B2(b) Both are ionic compounds with giant ionic lattice structure. The ionic bond strength is indicated by the magnitude of lattice energy (LE):

$$\left| \text{lattice energy} \right| \propto \left| \frac{q_+ \times q_-}{r_+ + r_-} \right|$$

Cs^+ has a bigger cationic radius than K^+, and therefore CsCl has longer inter-ionic distance than KCl. The magnitude of LE of CsCl is smaller than that of KCl. The ionic bonds in CsCl are weaker than that in KCl. Hence, melting point of CsCl is lower than that of KCl.

Examiner comments
- Students are required to identify that the difference in both ionic compounds is the cation (Cs^+ vs K^+).
- Students are required to compare either the cationic radius or interionic distance to determine which has a larger magnitude of LE.
- Students should avoid using "larger or smaller" when comparing LE. Instead, students are required to mention that LE is either more or less exothermic instead. Alternatively, students can compare the magnitude of LE.
- Students need to be very mindful of the species they are actually referring to. Here, it is the "caesium ion" i.e. Cs^+ being discussed, and not "caesium" / "caesium atom" i.e. Cs.
- Some misread the question and compared using $MgCl_2$ instead of KCl.
- Lattice energy is not inversely proportional to "ionic radius" but to "interionic distance". Also, lattice energy is not dependent on charge density.
- It is the cationic radius of Cs^+, and not the atomic radius of Cs, that is involved here.
- Students should keep your answer concise - there was no need to explain why Cs^+ has a bigger cationic radius than K^+.

B2(c)(i)



Examiner comments
- Students are required to show the dipole (δ+ on H atom and δ- on O atom of the water molecule). The δ- on O of H_2O should be forming the ion-dipole interaction with Na^+.
- Please use the correct symbol: δ and not ∂.
- Students are required to label the type of interaction present between Na^+ and H_2O molecule.
- Some students wrongly drew O–H–O instead of H–O–H.
- There is no δ+ on Na^+ (as Na has lost one electron and is not possessing any partial charges here).

B2(c)(ii) Na^+ having a smaller ionic radius has a higher charge density. Hence it attracts more water molecules per ion in the aqueous state compared to Cs^+ (more extensively hydrated in aqueous). This results in the hydrated Na^+ ion having a bigger size compared to Cs^+, which makes it less mobile.

Examiner comments
- Some talked about having more / stronger ion-dipole interactions but did not relate it to how this impacted conductivity.
- Students are required to draw the clue from the question that "larger ions may experience more resistance from the surrounding medium, making them less mobile" and lower conductivity. Hence, students would need to think about how to relate the ionic radius to charge density and extent of ion-dipole interaction with H_2O molecules and hence affecting the resistance to move in the surrounding medium.

B2(d)(i) Percentage ionic character = $(1 - e^{-0.25\,(\Delta EN)}) \times 100\%$

$= (1 - e^{-0.25\,|3.16 - 1.61|}) \times 100\%$

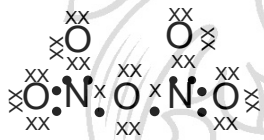
$= 32.1\%$

Examiner comments
- This was generally well done.

B2(d)(ii) The percentage ionic character is low as calculated in **(d)(i)**. $AlCl_3$ has a simple molecular structure and does not have mobile charge carriers to conduct electricity.

Examiner comments
- Many merely stated that the ionic character was low but did not go on to elaborate about the covalent / molecular aspects (which can then be related to the lack of mobile charge carriers) relevant in this context.

B3(a)



According to VSEPR theory, there are 2 bond pairs and 2 lone pairs of electrons around the O atom. To minimise electronic repulsion between the electron pairs, the shape around the O atom is bent, and the bond angle is 105°.

Examiner comments
- In dot-and-cross diagrams, all lone pairs (including the valence electrons on the peripheral O atoms) must be shown. The general exception to this is when we give the dot-and-cross of the metallic cation – see Q2b(a).
- Note that N in period 2, cannot expand octet. It would be incorrect to draw dot-and-cross diagrams with more than 8 electrons around N.
- Please include the number of bond pairs when describing how shape is predicted: some just stated there are 2 lone pairs but made no reference to the number of bond pairs.

B3(b)(i) $pV = nRT$

$n = \frac{pV}{RT}$

$= \frac{(72.46 \times 10^3) \times (1.00 \times 10^{-3})}{8.31\,(30 + 273)}$

$= 0.02877$

$= 0.0288$ mol (to 3 s.f)

average $M_r = \frac{1.242}{0.02877}$

$= 43.158$

$= 43.2$ (to 3 s.f)

Examiner comments
- Note that M_r has no units but molar mass, M, has units.
- Students are required to convert the terms into SI units (eg. dm^3 to m^3, kPa to Pa, ^oC to K) when substituting the values into the ideal gas equation.

B3(b)(ii) M_r of NO_2 = 46.0 M_r of O_2 = 32.0

Let the mole fraction of NO_2 be x
Mole fraction of O_2 = 1−x
x(46.0) + (1−x)(32.0) = 43.158
x = 0.797

Partial pressure of NO_2
= 0.797 x 72.46
= 57.8 kPa (to 3 s.f)

Examiner comments
- Avoid leaving your answers in fractions, unless the question asks for it.

B3(c)(i)

pressure / kPa	volume / m^3	pV / kPa m^3
6.0	0.060	0.360
12.0	0.030	0.360
18.0	0.020	0.360

Since the pV values calculated at different pressures are constant at 0.360, this sample of oxygen is exhibiting ideal gas behaviour.

Examiner comments
- Here, students are expected to clearly make use of the data given (e.g. show some calculations involving the given numbers), and not simply state general statements like "when pressure increases, volume decreases" since a real gas not behaving ideally can also exhibit what is stated.
- Some went to prove that the number of moles of gas remain unchanged, which is not meaningful since there is no reaction here, and whether it is a real or ideal gas, the number of moles of gas should not change regardless of the resultant p or V.

B3(c)(ii) The temperature is (sufficiently) high at 1000 K and the pressure is (sufficiently) low.

Examiner comments
- Students are required to comment on both temperature and pressure conditions for the sample to exhibit ideal gas behaviour.

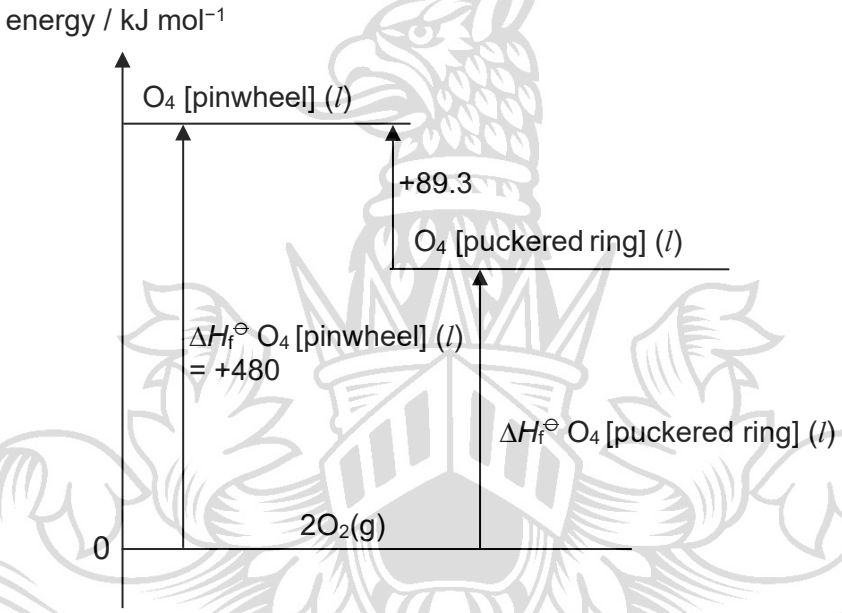
B3(d)(i) Each O atom in the square structure has 2 bond pairs and 2 lone pairs of electrons, the bond angle around O atom is expected to be 105°, however, the bond angles are forced to be 90° in the square structure. Thus the bond pairs of electrons are forced to be closer together, leading to increased repulsion, resulting in strain in the structure, causing it to be unstable.

Examiner comments
- Students are required to use the VSEPR to think about if the bond pairs are too close to each other and hence, leading to repulsion between the bond pairs, causing the compound to be unstable. To do so, they would need to use VSEPR to decide on what should have been the angle between the bond pairs to minimise the repulsion between the bond pairs.
- Do not use random angles – the basis for discussion should always be primarily the reference angles based on known shapes e.g. 105° (bent) 107° (trigonal pyramidal) 109° (tetrahedral), unless the context of the question requires otherwise.

B3(d)(ii) The standard enthalpy change of formation ($\Delta H_f^{\ominus}$) of a substance is the energy change when 1 mole of the pure substance in a specified state is formed from its constituent elements in their standard states under standard conditions of 1 bar and 298 K.

Examiner comments
- Please be familiar with all definitions.
- Here, it is energy “change”, not “released” or “absorbed” – please use the correct term for the relevant definition.
- The standard conditions must be stated clearly.
- The temperature at standard conditions is not “273 K”.

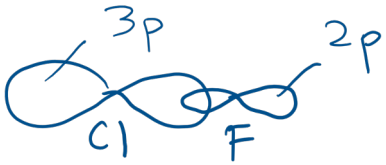
B3(d)(iii)



Based on the diagram,
$\Delta H_f^{\ominus}$ O_4 [puckered ring] (l) = 480 – 89.3
= +390.7 kJ mol^{-1}
= +391 kJ mol^{-1} (3 s.f.)

Examiner comments
- The constituent element of O_4 is oxygen, and it exists as O_2(g) in the standard state. Do indicate the elements at standard state to be at “0” kJ mol^{-1} energy level.
- The energy level diagram needs to be closed before Hess’s Law can be applied.
- Students are reminded that the direction of the arrow should correspond to the sign of the enthalpy change that they are representing.

C1(a)(i)



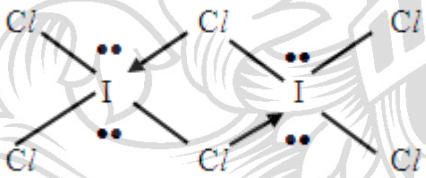
The σ bond between C*l* and F is formed by the head-on/ collinear/ head-to-head overlap of a 2p orbital of F and a 3p orbital of C*l*.

Examiner comments
• The difference in size should be clearly shown, and students are required to state clearly the orbitals that are involved in the formation of the bond. • It is an "overlap", not a head-to-head "collision".

C1(a)(ii) F, a period 2 element, does not have vacant, low-lying orbitals for expansion of octet and hence cannot accommodate more than 8 electrons around it.

Examiner comments
• Students need to explain why the expansion of octet is not possible here, and not just state "cannot expand octet". • "Orbitals", not "d-orbitals".

C1(a)(iii)



Examiner comments
• There should be lone pairs indicated on the two iodine atoms to show the shape as required by the questions. • Students can make reference to the structure of Al_2Cl_6 to draw the structure of I_2Cl_6. Cl forms a dative bond with I (Cl → I).

C1(a)(iv) Chlorine is a smaller atom compared to iodine, so it cannot 'pack' as many fluorine atoms around itself, due to repulsion of electron clouds between the F atoms.

Examiner comments
• Students should realise that both chlorine and iodine are able to expand their octet and hence, should no longer be used as a reason to explain the difference.

C1(a)(v) Both have simple molecular structure with weak intermolecular forces of attraction.

IC*l* is a polar molecule whereas Br_2 is a non-polar molecule.

More energy is required to overcome the stronger instantaneous dipole-induced dipole and permanent dipole-permanent dipole interactions between IC*l* molecules than the weaker instantaneous dipole-induced dipole interactions between Br_2 molecules.

Examiner comments
• The structure should be clearly stated i.e. simple molecular structure. • Please spell correctly "instantaneous". • As 3 marks are allocated to this question, students are required to identify that IC*l* is polar while Br_2 isn't before moving on to compare the difference in the strength of the different intermolecular forces of attraction present in both molecules. • Students should note that the electron cloud size can be found by counting the total number of electrons, not by obtaining the M_r.

C1(b)(i) +5

Examiner comments
• Not "5+" as this would then be for the charge on an ion e.g. $X^{5+}(g)$.

C1(b)(ii) $ClO_3^- + 6H^+ + 6e^- \longrightarrow Cl^- + 3H_2O$

$SO_2 + 2H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e^-$

$ClO_3^- + 3SO_2 + 3H_2O \longrightarrow Cl^- + 3SO_4^{2-} + 6H^+$

Examiner comments
• Students are reminded that the mass and charge should be balanced in half equations and overall equation. • In writing half-equations, 'O' should be balanced by adding 'H_2O', not 'O_2'.

C1(b)(iii) amount of $AgCl$ = amount of Cl^- in the mixture

$= \frac{0.0370}{143.4}$ mol = 2.58×10^{-4} mol

amount of SO_2 present in 100 cm^3 = $2.58 \times 10^{-4} \times 3$
= 7.74×10^{-4} mol

mass of SO_2 present in 100 cm^3 = $7.74 \times 10^{-4} \times 64.1$
= 4.96×10^{-2} g

Examiner comments
• Students are required to know that the amount of Cl^- in the mixture is equivalent to the amount of $AgCl$ that has been obtained when $AgNO_3$ is added to the resultant solution.

C1(b)(iv) mass of SO_2 in 1 dm^3 = $4.96 \times 10^{-2} \times \frac{1000}{100}$
= 0.496 g
= 496 mg

concentration of SO_2 = 496 mg in 1 dm^3
= 496 ppm

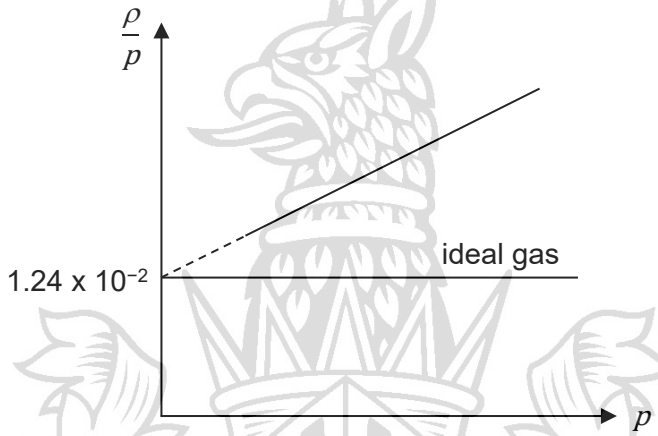
It has exceeded the maximum concentration allowed.

Examiner comments
• Students are required to show calculations and compare it with the allowed concentration of 350 ppm before concluding that the concentration exceeded the maximum concentration.

C2(a)(i) An ideal gas consists of <u>particles of negligible volume</u>.
The gas particles <u>exert negligible attractive forces</u> on one another.

Examiner comments
• Students are required to make reference to the particles of the ideal gas when stating about negligible volume.

C2(a)(ii)



Examiner comments
• Please label as instructed. • As p approaches 0 Pa, Gas **D** approaches ideal gas behaviour. Hence the given graph when extrapolated to the y-axis gives the value of $\frac{\rho}{p}$ at p = 0 Pa, i.e. y-intercept gives the value for an ideal gas at p = 0 Pa. Using $pV = nRT = \frac{m}{M}RT$, $\frac{\rho}{p} = \frac{M}{RT}$, where $\rho = \frac{m}{V}$. At constant T, the value of $\frac{\rho}{p}$ for an ideal gas is a constant $\left(= \frac{M}{RT}\right)$ regardless of p, so the graph of $\frac{\rho}{p}$ against p for an ideal gas is a horizontal line.

C2(a)(iii) $\frac{\rho}{p} = \frac{M}{RT}$

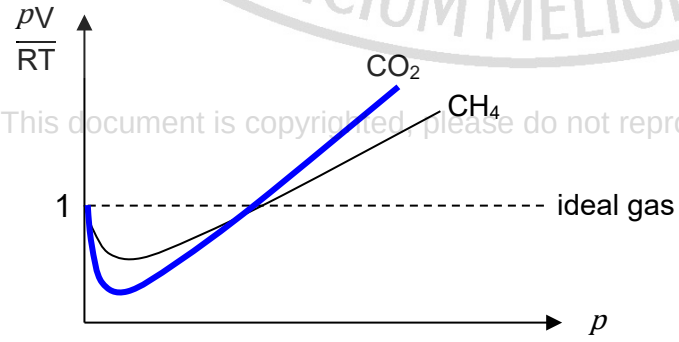
$M = 1.24 \times 10^{-2} \times 8.31 \times 273 = 28.1$ g mol^{-1}
Therefore, M_r = 28.1

Examiner comments
• Students are reminded that M_r should have no units.

C2(a)(iv) CO

Examiner comments
• Students are required to suggest a gaseous pollutant that matches the M_r. Note that N_2 with the same M_r is not a pollutant.

C2(b)(i)



CO_2 deviates more from ideal behaviour at moderately high pressure compared to CH_4 since it has stronger instantaneous dipole-induced dipole interactions due to its larger and more polarisable electron cloud.

Examiner comments
- Please label as instructed.
- Spell out "instantaneous dipole-induced dipole" in full.
- Students are required to state clearly about why CO_2 has stronger id-id interactions.
- CO_2 has a linear shape, the bond dipoles cancel out and it is non-polar.

C2(b)(ii) $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$
$H_2(g) + ½O_2(g) \longrightarrow H_2O(l)$

Examiner comments
- When asked to write equation to represent an enthalpy change, state symbols MUST be given.
- Many students gave the equation $2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$ to represent $\Delta H_c(H_2(g))$. This is incorrect as $\Delta H_c(H_2(g))$ is the energy change when 1 mol of H_2 is completely burnt in excess O_2.
- At r.t.p. (as specified in the question), H_2O is in the liquid state.

C2(b)(iii) $n(CH_4) = (70/71)(100/24000) = \underline{4.108 \times 10^{-3}}$ mol
$n(H_2) = (1/71)(100/24000) = \underline{5.869 \times 10^{-5}}$ mol

Heat evolved $= (4.108 \times 10^{-3})(880) + (5.869 \times 10^{-5})(280)$
$= \underline{3.63 \text{ kJ}}$

Examiner comments
- Some students were unable to calculate amount of H_2 and CH_4. Students are reminded that under r.t.p. conditions, $n_{gas} = \frac{V_{gas}\ (\text{in cm}^3)}{24000}$ or $\frac{V_{gas}\ (\text{in dm}^3)}{24}$.
- Heat evolved = $n(H_2) \times \Delta H_c(H_2) + n(CH_4) \times \Delta H_c(CH_4)$ and should not carry a sign.

C2(b)(iv) From (b)(ii), combustion of H_2 results in a decrease in entropy ($\Delta S < 0$).

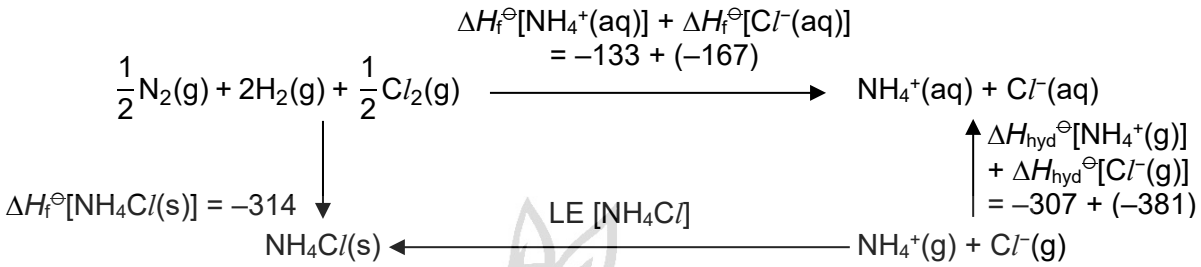
Hence $T\Delta S$ is a negative term and the reaction is only spontaneous at low temperatures, T, where $|T\Delta S| < |\Delta H|$ such that $\Delta G < 0$.

Examiner comments
- Generally well done.
- Many students were able to deduce that $\Delta S < 0$, but fewer students concluded that $\Delta G < 0$ (for spontaneous reaction) could occur only for low temperatures specifically.
- Students should comment on the sign of ΔG when discussing spontaneity.

C2(c)(i) The standard enthalpy change of hydration ($\Delta H_{hyd}^{\ominus}$) of an ion is the energy released when 1 mole of gaseous ions is dissolved in water to form 1 mole of aqueous ions under standard conditions (i.e. 1 bar and 298 K).

Examiner comments
- Here, it is energy "released", not "change" or "absorbed" – please use the correct term for the relevant definition.
- A common error was omitting any reference to water.

C2(c)(ii)



LE$[NH_4Cl]$ = –307 + (–381) – (–133) – (–167) + (–314)
= –702 kJ mol^{-1}

Examiner comments
• Students are required to balance each equation in the cycle with the direction of arrow corresponding to the enthalpy change represented.

C2(c)(iii) $\Delta H_{sol}^{\ominus}[NH_4Cl] = \Delta H_{hyd}^{\ominus}[NH_4Cl] – LE[NH_4Cl]$
= –307 + (–381) – (–702)
= +14.0 kJ mol^{-1}

Examiner comments
• Students need to know the definition of enthalpy change of solution and hence, how to calculate from the enthalpy change of hydration and lattice energy terms given.

C2(c)(iv) Ice pack

Examiner comments
• Students are required to suggest an application based on their answers in (c)(iii).