

NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE
NAME

SUBJECT
CLASS

REGISTRATION
NUMBER

CHEMISTRY

Paper 1 Multiple Choice

9729/01

23 September 2025

1 hour

Additional Materials: Optical Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

Instructions on how to fill in the Optical Mark Sheet

Shade the index number in a 5 digit format on the optical mark sheet:

2nd digit and the last 4 digits of the Registration Number.

Example:

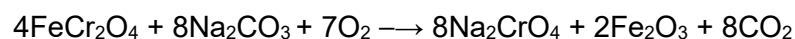
Student	Examples of Registration No.	Shade:
	<u>2405648</u>	45648

This document consists of **16** printed pages.

Answer Key for P1 (MCQ)

1	A	6	C	11	C	16	C	21	C	26	D
2	D	7	C	12	C	17	B	22	A	27	C
3	A	8	C	13	B	18	D	23	D	28	C
4	B	9	B	14	B	19	C	24	C	29	C
5	B	10	D	15	A	20	C	25	C	30	A

- 1 Sodium chromate(VI), Na_2CrO_4 , is manufactured by heating chromite, FeCr_2O_4 , with sodium carbonate in an oxidising atmosphere. Chromite contains $\text{Cr}_2\text{O}_4^{2-}$ ions.



What happens in this reaction?

- A Chromium and iron are the only elements oxidised.
 B Chromium, iron and carbon are oxidised.
 C Only chromium is oxidised.
 D Only iron is oxidised.

Ans: A

Reactants: FeCr_2O_4 (Fe = +2 and Cr = +3), Na_2CO_3 (C = +4), O_2 (O = 0).

Products: Fe_2O_3 (Fe = +3), Na_2CrO_4 (Cr = +6), CO_2 (C = +4).

Changes:

Fe: +2 \rightarrow +3 (**oxidised**)

Cr: +3 \rightarrow +6 (**oxidised**)

C: +4 \rightarrow +4 (**no change**)

O: 0 \rightarrow -2 (**reduced**)

So, only Fe and Cr are oxidised.

- 2 Which species has two unpaired electrons?

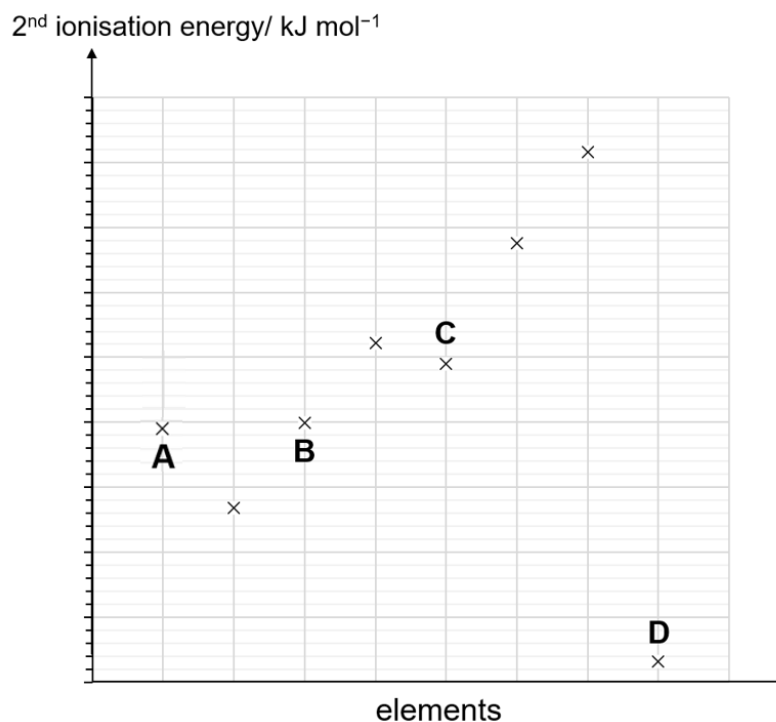
- A B^+ B Cu^+ C Mg D S

Ans: D

B^+ : $1s^2 2s^2$	No unpaired electrons
Cu^+ : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$	No unpaired electrons
Mg: $1s^2 2s^2 2p^6 3s^2$	No unpaired electrons
S: $1s^2 2s^2 2p^6 3s^2 3p^4$	2 unpaired 3p electrons

- 3 The variation in the second ionisation energy of eight consecutive elements in the Periodic Table with atomic numbers ≤ 20 is shown in the graph.

Which element is a Group 13 element?



Ans: A

The large drop in 2nd I.E. shows that **D**⁺ ion has the ns¹ electronic configuration. Hence, the electronic configuration of element **D** is ns² and belongs to Group 2. Since the graph is showing consecutive elements in the Periodic Table, the configuration of the other elements can be derived.

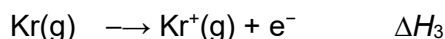
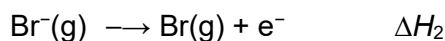
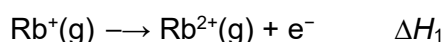
- A – Group 13
- B – Group 15
- C – Group 17
- D – Group 2

- 4 What do the ions $^{15}\text{N}^{3-}$ and $^{14}\text{C}^{4-}$ have in common?
- A They have 10 neutrons in their nuclei.
- B They have more electrons than neutrons.
- C They have a valence electronic configuration of $3s^2 3p^6$.
- D They contain the same number of nucleons in their nuclei.

Ans: B

species	$^{15}\text{N}^{3-}$	$^{14}\text{C}^{4-}$
number of protons	7	6
number of neutrons	8	8
number of electrons	10	10
number nucleons	15	14
valence electron configuration	$2s^2 2p^6$	$2s^2 2p^6$

- 5 What is the order of decreasing enthalpy change for the three reactions shown?



- A $\Delta H_1 > \Delta H_2 > \Delta H_3$
- B $\Delta H_1 > \Delta H_3 > \Delta H_2$
- C $\Delta H_2 > \Delta H_1 > \Delta H_3$
- D $\Delta H_2 > \Delta H_3 > \Delta H_1$

Ans: B

All 3 equations are for ionisation energy.

Rb^+ , Br^- and Kr are isoelectronic with 36 electrons.

Nuclear charge increases from $\text{Br}^- < \text{Kr} < \text{Rb}^+$ while shielding effect remains constant.

Nuclear attraction for the most loosely held electron increases from $\text{Br}^- < \text{Kr} < \text{Rb}^+$.

Largest amount of energy is required to remove the most loosely held electron from Rb^+ .

- 6 Barium dithionate, $\text{BaS}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$, is soluble in water.

$\text{S}_2\text{O}_6^{2-}$ ions slowly decompose in acidic solution.



3.513 g of $\text{BaS}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$ is dissolved in some water and the solution made up to the mark with $\text{HCl}(\text{aq})$ in a 100 cm^3 volumetric flask.

At time x min, a white precipitate of mass 0.661 g is present in the flask.

What is the concentration of BaS_2O_6 in the volumetric flask at time x min?

[A_r : Ba, 137.3; S, 32.1; O, 16.0; H, 1.0]

A 0.0077 mol dm^{-3}

B 0.0090 mol dm^{-3}

C 0.077 mol dm^{-3}

D 0.090 mol dm^{-3}

Ans: C

$$\text{Amount of } \text{BaS}_2\text{O}_6 \cdot 2\text{H}_2\text{O} = \frac{3.513 \text{ g}}{(137.3 + 32.1 \times 2 + 16.0 \times 6 + 18.0 \times 2)} = 0.01053 \text{ mol}$$

The white ppt is BaSO_4 .

$$\text{Amount of } \text{BaSO}_4 = \frac{0.661 \text{ g}}{(137.3 + 32.1 + 16.0 \times 4)} = 0.002831 \text{ mol}$$

$$\text{Amount of } \text{BaS}_2\text{O}_6 \text{ at } x \text{ min} = 0.01053 - 0.002831 = 0.007698 \text{ mol}$$

$$[\text{BaS}_2\text{O}_6] \text{ at } x \text{ min} = \frac{0.007698}{\frac{100}{1000}} = 0.077 \text{ mol dm}^{-3}$$

- 7 $\text{NH}_4\text{Fe}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ is a hydrated 'double salt'. A student analyses this double salt using the following chemical tests.

Which row gives the correct result for the stated test?

	Test	Results
1	Reaction with cold $\text{NaOH}(\text{aq})$	Green ppt
2	Reaction with $\text{Ba}(\text{NO}_3)_2(\text{aq})$	White ppt
3	Reaction with warm $\text{NaOH}(\text{aq})$	Red-brown ppt and an alkaline gas

- A** 1, 2 and 3 **B** Only 1 and 2 **C** Only 2 and 3 **D** Only 1

Ans: C

In the double salt, oxidation state of Fe is +3.

1 is a wrong result. With cold $\text{NaOH}(\text{aq})$, $\text{Fe}(\text{OH})_3$ red-brown ppt is formed.

2 is a correct result. BaSO_4 white ppt is formed.

3 is a correct result. With warm $\text{NaOH}(\text{aq})$, as NH_4^+ is present, NH_3 gas will be given off.

At the same time, $\text{Fe}(\text{OH})_3$ red-brown ppt is formed.

- 8 Which statements about BF_3 and NF_3 are correct?

- The shape of BF_3 is trigonal planar while that of NF_3 is trigonal pyramidal.
- Both BF_3 and NF_3 are polar molecules.
- BF_3 can act as a Lewis acid because the boron atom has empty low-lying orbitals.

- A** 1 and 2 **B** 2 and 3 **C** 1 and 3 **D** 1, 2 and 3

Ans: C

Statement 1: Shapes

- BF_3 : central B, 3 bonding pairs, 0 lone pairs → **trigonal planar**.
- NF_3 : central N, 3 bonding pairs, 1 lone pair → **trigonal pyramidal**.

So statement 1 is correct.

•

Statement 2: Polarity

- BF_3 : although each B–F bond is polar, the **symmetry (trigonal planar)** cancels dipoles → **non-polar molecule**.
- NF_3 : asymmetric, lone pair on N, net dipole → **polar molecule**.

So statement 2 is incorrect (only NF_3 is polar).

Statement 3: Lewis acidity

BF_3 : central B has an **empty 2p orbital (low-lying, energetically accessible)** → can accept lone pair electron from a donor.

So statement 3 is correct.

- 9 Silicon carbide has a similar structure to diamond.

Silicon carbide can be used as

- A a lubricant.
- B a tip for cutting tools.
- C a substitute for pencil 'lead'.
- D an electrical conductor.

Ans: B

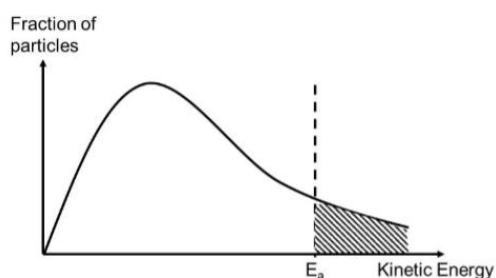
Diamond: each sp^3 hybridised C atom forms strong covalent bond with 4 other C atoms in a tetrahedral arrangement in the giant covalent lattice structure. Properties of diamond include: very high melting point, non-electrical conductor, hard, insoluble in all solvents.

- 10 Which statement is **not** a basic assumption of the kinetic theory of gases?

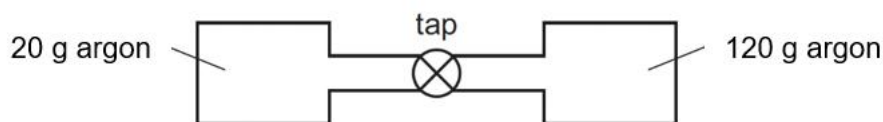
- A The atoms or molecules have negligible size in comparison with the space they occupy.
- B There are negligible intermolecular forces between the gas particles.
- C Collisions between the individual particles and the vessel are perfectly elastic.
- D The particles of a given gas have the same kinetic energy at a given temperature.

Ans: D

The particles of a given gas do not have the same kinetic energy at a given temperature, in fact, they have a range of kinetic energies, as represented in the Boltzmann distribution curve.



- 11 The diagram below shows two containers of argon gas connected by a closed tap. Each container has a volume of 500 dm^3 .



The temperature of the system is changed to 250°C and the tap is opened.

What is the pressure of argon within the system at 250°C ?

- A** 7.29 kPa **B** 14.6 kPa **C** 15.3 kPa **D** 30.5 kPa

Ans: C

$$\text{Total no. of mol of Ar} = \frac{20}{39.9} + \frac{120}{39.9} = 3.509 \text{ mol}$$

$$\text{Final volume (both } 500 \text{ dm}^3 \text{ vessels connected)} = 1000 \text{ dm}^3 = 1 \text{ m}^3$$

$$\text{Final Temperature, } T = 250 + 273 = 523\text{K}$$

Apply $pV=nRT$

$$P = \frac{nRT}{v} = \frac{3.509 \times 8.31 \times 523}{1} = 15\,251 \text{ Pa} = 15.3 \text{ kPa (3 s.f.)}$$

- 12 The standard enthalpy change of combustion of but-1-ene, $\text{CH}_2=\text{CHCH}_2\text{CH}_3(\text{g})$, is $x \text{ kJ mol}^{-1}$.

The standard enthalpy change of the reaction $2\text{C}_2\text{H}_4(\text{g}) \longrightarrow \text{CH}_2=\text{CHCH}_2\text{CH}_3(\text{g})$ is $y \text{ kJ mol}^{-1}$.

What is the standard enthalpy change of combustion of ethene, $\text{C}_2\text{H}_4(\text{g})$?

A $\frac{x}{2} + y \text{ kJ mol}^{-1}$

B $x + \frac{y}{2} \text{ kJ mol}^{-1}$

C $\frac{x+y}{2} \text{ kJ mol}^{-1}$

D $\frac{x-y}{2} \text{ kJ mol}^{-1}$

Ans: C

$$\Delta H_r = 2(\Delta H_c \text{ C}_2\text{H}_4) - \Delta H_c \text{ CH}_2=\text{CHCH}_2\text{CH}_3$$

$$y = 2(\Delta H_c \text{ C}_2\text{H}_4) - x$$

$$\Delta H_c \text{ C}_2\text{H}_4 = \frac{x+y}{2} \text{ kJ mol}^{-1}$$

13 Which suggested mechanism is consistent with the experimentally-obtained rate equation?

	rate equation	suggested mechanism
A	$\text{rate} = k[\text{N}_2\text{O}][\text{H}_2]$	$2\text{NO} + \text{H}_2 \longrightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$ $\text{N}_2\text{O} + \text{H}_2 \xrightarrow{\text{slow}} \text{N}_2 + \text{H}_2\text{O}$
B	$\text{rate} = k[\text{NO}]^2[\text{H}_2]^2$	$2\text{NO} + \text{H}_2 \longrightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$ $\text{N}_2\text{O} + \text{H}_2 \xrightarrow{\text{slow}} \text{N}_2 + \text{H}_2\text{O}$
C	$\text{rate} = k[\text{H}_2\text{O}_2][\text{I}^-]$	$\text{H}_2\text{O}_2 + \text{I}^- \longrightarrow \text{IO}^- + \text{H}_2\text{O}$ $\text{H}_2\text{O}_2 + \text{IO}^- \xrightarrow{\text{slow}} \text{I}^- + \text{H}_2\text{O} + \text{O}_2$
D	$\text{rate} = k[\text{H}_2\text{O}_2][\text{IO}^-]$	$\text{H}_2\text{O}_2 + \text{I}^- \longrightarrow \text{IO}^- + \text{H}_2\text{O}$ $\text{H}_2\text{O}_2 + \text{IO}^- \xrightarrow{\text{slow}} \text{I}^- + \text{H}_2\text{O} + \text{O}_2$

Ans: B

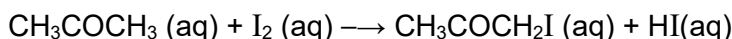
For A and D, N_2O and IO^- are intermediates so they cannot appear in the rate equation.

For C, the rate equation in the option is for the first step but the first step is not the slow step.

Hence A, C and D are wrong.

For B, $\text{rate} = k[\text{N}_2\text{O}][\text{H}_2]$ since the second step is the slow step. N_2O is formed from the first step and it involves 2NO and 1H_2 , hence the rate equation after substituting N_2O as 2NO and 1H_2 is $\text{rate} = k[\text{NO}]^2[\text{H}_2]^2$.

- 14 Propanone reacts with iodine in the presence of sulfuric acid.



The rate equation for this reaction is: $\text{rate} = k[\text{H}^+][\text{CH}_3\text{COCH}_3]$.

Two experiments were carried out. In both experiments, the initial concentrations of propanone and iodine remained the same but the initial concentration of the sulfuric acid was changed. The initial rate in the first experiment was three times faster than the initial rate in the second experiment. In the first experiment the initial pH was 1.50.

What is the initial pH in the second experiment?

- A** 1.02 **B** 1.98 **C** 2.28 **D** 4.50

Ans: B

As conc of propanone is kept constant,

$$\frac{\text{rate (1)}}{\text{rate (2)}} = \frac{k(10^{-1.50})}{k[\text{H}^+]}$$

$$\frac{3}{1} = \frac{(0.03162)}{[\text{H}^+]}$$

$$[\text{H}^+] = 0.01054 \text{ mol dm}^{-3}$$

$$\text{pH} = -\lg 0.01054 = 1.977 \approx 1.98$$

- 15 Which factor contributes to $\text{Ba}(\text{NO}_3)_2$ decomposing at a higher temperature than $\text{Mg}(\text{NO}_3)_2$?

- A** The charge density of the Ba^{2+} ion is lower than that of the Mg^{2+} ion.
B The standard enthalpy change of formation of BaO is more negative than that of MgO .
C The lattice energy of $\text{Ba}(\text{NO}_3)_2$ is less negative than that of $\text{Mg}(\text{NO}_3)_2$.
D The melting point of $\text{Ba}(\text{NO}_3)_2$ is higher than that of $\text{Mg}(\text{NO}_3)_2$.

Ans: A

A. The charge density of the Ba^{2+} ion is lower than that of the Mg^{2+} ion.

✓ Correct. This means Ba^{2+} polarises the NO_3^- ion less \rightarrow nitrate is more stable \rightarrow requires higher temp to decompose.

B. The standard enthalpy change of formation of BaO is more negative than that of MgO .

X Wrong. In fact, ΔH_f of MgO is more negative (more exothermic) than BaO because Mg^{2+} has higher charge density. This option does not explain the trend in nitrate stability.

C. The lattice energy of $\text{Ba}(\text{NO}_3)_2$ is less negative than that of $\text{Mg}(\text{NO}_3)_2$.

X True statement, but not the controlling factor for *thermal stability of the nitrate*. Lattice energies relate more to ionic size and packing, not directly to decomposition temperature.

D. The melting point of $\text{Ba}(\text{NO}_3)_2$ is higher than that of $\text{Mg}(\text{NO}_3)_2$.

X Irrelevant. Melting point is not the reason for differences in thermal stability of nitrates.

- 16 Which statement explains the trend of decreasing volatility from HCl to HI ?

- A** The electronegativity between the bonded atoms increases.

- B** The molecules are polar and they have increasingly stronger permanent dipole-permanent dipoles.
- C** There are more electrons in iodine atom than in chlorine atom.
- D** The bond length decreases from H-Cl to H-I, hence thermal stability increases.

Ans: C

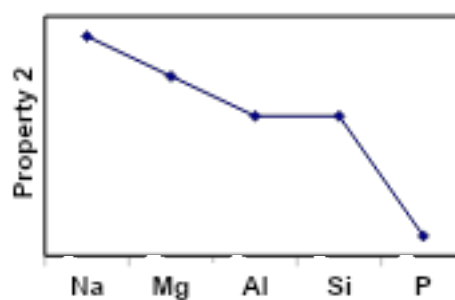
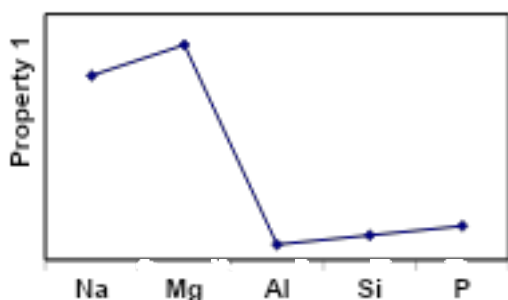
Decreasing volatility means increasing boiling point / stronger intermolecular forces of attraction.

The difference in electronegativity between the H and the halogen decreases from HCl to HI, i.e. HI is the least polar and hence the pd-pd between H I is the weakest. This does not help to explain the trend.

Instead, the size of electron cloud increases from HCl to HI, resulting in stronger instantaneous dipole-induced dipole interactions (id-id) which help to explain the trend.

The covalent H-X bonds are not broken during boiling, so option D is irrelevant.

- 17** The graphs below show the variation of two properties of some Period 3 elements and/or their compounds.



Which option correctly describes properties 1 and 2?

	Property 1	Property 2
A	atomic radius of the elements	electrical conductivity of the elements
B	boiling point of the chlorides at the highest oxidation states	pH of the oxides when added to water
C	melting point of the oxides	first ionisation energies of the elements
D	electrical conductivity of elements	pH of the chlorides at the highest oxidation states when added to water

Ans: B

For option A

Property 1 cannot be atomic radii as it should be a continuous decrease across the period due to increase in nuclear attraction for the outermost electron. This is because of increase in nuclear charge but constant shielding caused by the same number of inner electrons.

Property 2: Electrical conductivity should increase from Mg to Al due to increase in number of mobile charged carriers (more electrons in the sea of delocalised electrons). Electrical conductivity should be very low for Si while P exhibit zero electrical conductivity. Hence graph shows a wrong trend for electrical conductivity.

For option B

Boiling point of chloride compounds decreases from NaCl to AlCl₃ as AlCl₃ is a simple covalent molecule therefore easier to overcome the intermolecular temporary dipole induced dipole than ionic bonds in giant ionic lattice of NaCl and MgCl₂.

From AlCl₃ to PCl₅, they have the structure of simple covalent molecules with Mr of AlCl₃ (133.5) < SiCl₄ (170.1) < PCl₅ (208.5). B.pt increases with increasing ease of distortion of the electron cloud of the chloride compound.

Hence property 1 shows the correct trend in the b.pt of chlorides across period 3 element.

Property 2: **acid base property of oxide** depends on the **nature of bonds present in the oxide** compound. While ionic oxide tends to be basic and covalent oxide is acidic; ionic oxides with significant covalent character will be amphoteric, this is usually observed when cation has high charge/size ratio.

pH of oxides in aqueous medium not only depends on the nature of the bonds, **solubility** also matters.

Na₂O is **basic and fully soluble** in water, therefore pH very high (highly alkaline).

Solubility of MgO less than Na₂O but more than Al₂O₃, hence pH of MgO > Al₂O₃.

pH of Al₂O₃ and SiO₂ are both equal to 7 because both are insoluble in water but Al₂O₃ is an amphoteric oxide while SiO₂ is an acidic oxide.

Oxides of P dissolves in water to give phosphoric acid therefore pH is very low.

Hence property 2 shows the correct trend for pH of aqueous oxides across period 3.

For option C

Melting points of oxides across the period should peak at SiO₂ since it has a very strong giant covalent lattice.

Phosphoric oxide is a simple covalent molecule, therefore there should be a drastic drop of m.pt from SiO₂ to P₄O₁₀. Hence property 1 cannot be m.pt of oxides across period 3 elements.

First ionisation energy of elements across period should exhibit a general increasing trend due to increasing nuclear attraction for the most loosely held electron. This is due to increase in nuclear charge but constant shielding effect by the same number of inner shell electrons.

Hence property 2 cannot be first ionisation energy.

For option D

Electrical conductivity should increase from Na to Mg to Al due to increase in number of mobile charged carriers

For chlorides across period 3 element, they are all soluble in aqueous medium. For chlorides that dissociates into ions in aq

(more electrons in the sea of delocalised electrons). Electrical conductivity should be very low for Si while P exhibit zero electrical conductivity. Hence graph shows a wrong trend for electrical conductivity.

medium, cation hydrolysis gives rise to acidic solution. Extent of cation hydrolysis increases with charge/size ratio of the cation. Hence $\text{AlCl}_3(\text{aq})$ more acidic than $\text{MgCl}_2(\text{aq})$ while NaCl is neutral ($\text{pH} = 7$)

On the other hand, covalent chlorides react with water to form HCl therefore the pH value should be low for both SiCl_4 and PCl_5 .

Hence graph of property 2 does not agree with the pH trend of aqueous chlorides across the period.

- 18** 10.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ of dilute sodium hydroxide was titrated against $0.100 \text{ mol dm}^{-3}$ of dilute ethanoic acid.

What is the volume of dilute ethanoic acid required to produce a buffer with maximum buffering capacity?

- A** 5.00 cm^3 **B** 10.00 cm^3 **C** 15.00 cm^3 **D** 20.00 cm^3

Ans: D

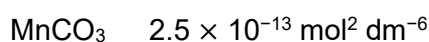
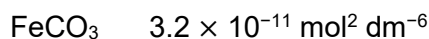
In this case, the buffer formed should contain a mixture of weak ethanoic acid and its ethanoate conjugate base. Excess ethanoic acid must be added to produce a buffer, making option **A** and **B** incorrect.

$V_{\text{eqv}} = 10.0 \text{ cm}^3$ (reaction involved a monobasic acid and a monobasic base with the same concentration).

Since maximum buffer capacity occurs when the concentration of ethanoic acid and the ethanoate conjugate base, $2V_{\text{eqv}} = 20.0 \text{ cm}^3$ of ethanoic acid must be added.

- 19** An acidified solution contains CaCl_2 , FeCl_2 and MnCl_2 , each of concentration 0.10 mol dm^{-3} . Carbon dioxide is blown through the solution until it is saturated with carbon dioxide at 25°C . The concentration of $\text{CO}_3^{2-}(\text{aq})$ in the saturated solution reaches $1 \times 10^{-9} \text{ mol dm}^{-3}$.

The value of the solubility product, K_{sp} , of each of the carbonates at 25°C is given below.



Which statement describes what happens in the solution?

- A** Only CaCO_3 and FeCO_3 are precipitated.
- B** Only CaCO_3 is precipitated.
- C** Only MnCO_3 and FeCO_3 are precipitated.
- D** Only MnCO_3 is precipitated.

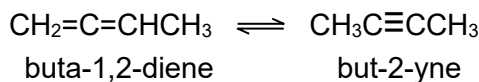
Ans: **C**

$$\text{Ionic product of } \text{MCO}_3 = [\text{M}^{2+}][\text{CO}_3^{2-}] = (0.1)(1 \times 10^{-9}) = 1 \times 10^{-10} \text{ mol}^2 \text{ dm}^{-6}$$

Since ionic product $> K_{\text{sp}}$ of FeCO_3 and K_{sp} of MnCO_3 , ppt of FeCO_3 and MnCO_3 will be formed.

Since ionic product $< K_{\text{sp}}$ of CaCO_3 , CaCO_3 will be soluble.

- 20 Buta-1,2-diene and but-2-yne both have the same molecular formula, C_4H_6 . They exist in equilibrium as shown:



Which bond is present in buta-1,2-diene but **not** present in but-2-yne?

- A a σ bond formed by s – sp overlap
 B a π bond formed by p – p overlap
 C a σ bond formed by sp – sp^2 overlap
 D a σ bond formed by sp^2 – sp^2 overlap

Ans: C

Buta-1,2-diene $CH_2=C=CHCH_3$
 hybridisation: sp^2 sp sp^2 sp^3

but-2-yne $CH_3C\equiv CCH_3$
 hybridisation: sp^3 sp sp sp^3

A	a σ bond formed by s – sp overlap: not present in both molecules
B	a π bond formed by p – p overlap: present in both molecules
C	a σ bond formed by sp – sp^2 overlap: C-C in butadiene, not in but-2-yne
D	a σ bond formed by sp^2 – sp^2 overlap : not present in both molecules

- 21 The chlorofluorocarbon, CCl_2F_2 , can cause the breakdown of ozone in the upper atmosphere.

Which initiation step could occur with ultraviolet radiation to catalyse this breakdown?

- A $CCl_2F_2 \rightarrow \cdot C + \cdot CCl_2F_2$
 B $CCl_2F_2 \rightarrow \cdot F + \cdot CCl_2F$
 C $CCl_2F_2 \rightarrow \cdot Cl + \cdot CClF_2$
 D $CCl_2F_2 \rightarrow \cdot CCl_2 + \cdot CF_2$

Ans: C

Option A shows an impossible reaction as C is the central atom.

Option B shows breaking of C-F bond which is too strong to be broken by UV radiation.

Option C shows breaking of C-Cl bond which is possible to be broken by UV radiation as it is weaker than C-F bond.

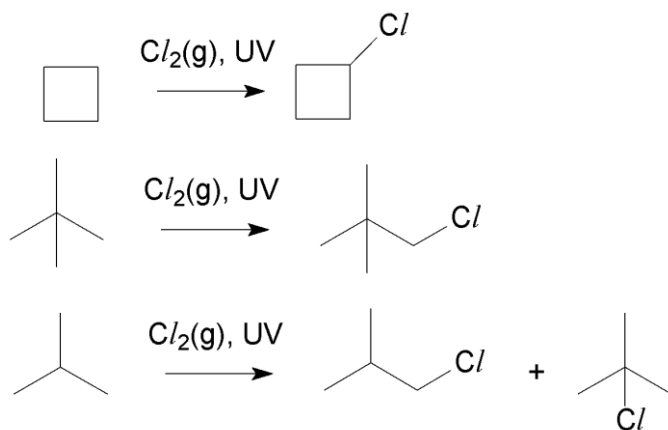
Option D is not possible as the 2 Cl are not bonded together in CCl_2F_2 .

22 Which hydrocarbons undergo substitution reactions to form only one monochloro-derivative?

- 1 cyclobutane
- 2 2,2-dimethylpropane
- 3 2-methylpropane

A 1 and 2 only **B** 2 and 3 only **C** 1 and 3 only **D** 1, 2 and 3

Ans: A

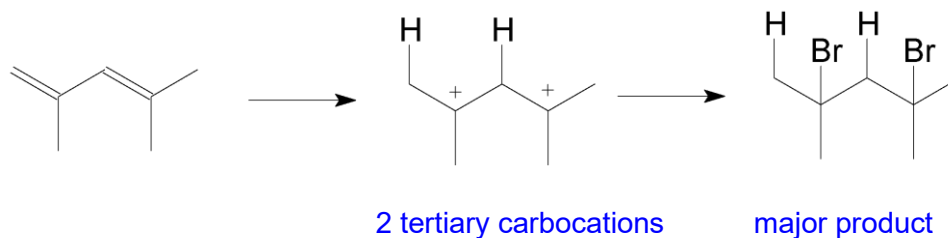


23 The alkene 2,4-dimethylpenta-1,3-diene reacts with two moles of HBr to give **X** as the major product.

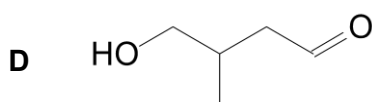
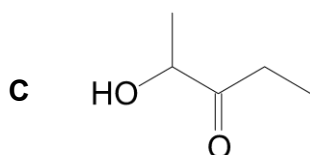
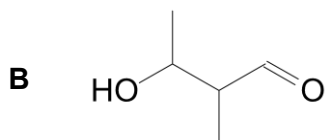
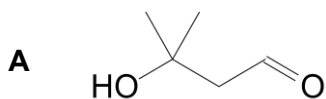
What is the structure of **X**?

- A** $\text{CH}_2\text{BrCH}(\text{CH}_3)\text{CH}_2\text{CBr}(\text{CH}_3)_2$
- B** $\text{CH}_2\text{BrCH}(\text{CH}_3)\text{CHBrCH}(\text{CH}_3)_2$
- C** $(\text{CH}_3)_2\text{CBrCHBrCH}(\text{CH}_3)_2$
- D** $(\text{CH}_3)_2\text{CBrCH}_2\text{CBr}(\text{CH}_3)_2$

Ans: D



- 24 Which compound can form an organic product with molecular formula $C_5H_8O_2$ when heated with excess acidified potassium dichromate(VI)?

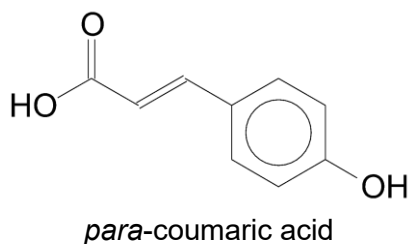


Ans: C

The number of O did not increase, so the compound cannot be any primary alcohols which will become carboxylic acids (increase by 1 O), or aldehydes which will become carboxylic acids (increase by 1 O).

The compound is the one with secondary alcohol(s) which will be oxidised to ketones (no change in number of O)

- 25 *Para*-coumaric acid is an antioxidant in coffee.



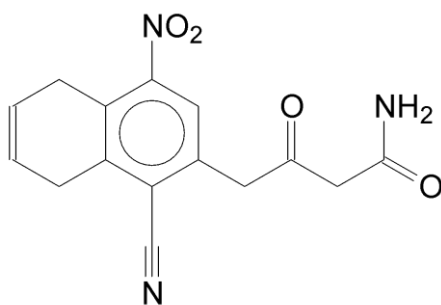
When treated with aqueous bromine, what is the maximum number of bromine atoms that can be incorporated into a molecule of *para*-coumaric acid?

- A 2 B 3 C 4 D 5

Ans: C

2 Br substituted on 2-position relative to OH

Maximum of 2 Br added across C=C (minor product)

**P**

When treated with each of the respective reagents, what is the number of hydrogen atoms that can be incorporated into a molecule of **P**?

	H ₂ , Ni	LiAlH ₄ in dry ether	NaBH ₄ in ethanol
A	6	6	4
B	6	8	4
C	8	6	2
D	8	8	2

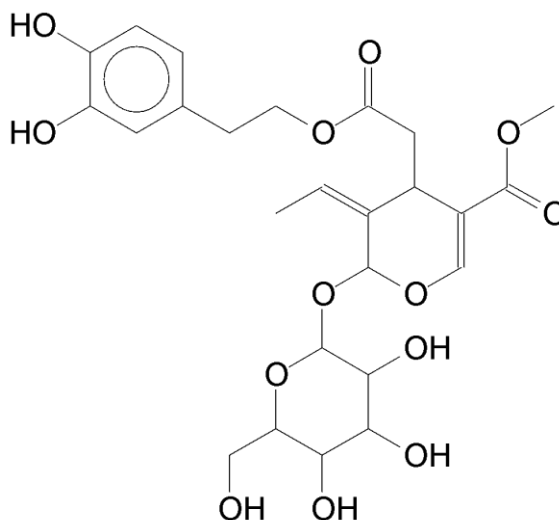
Ans: D

H₂, Ni can reduce C=C (+2H), CN (+4H), RCOR (+2H).

LiAlH₄ can reduce CN (+4H), RCOR (+2H), CONH₂ (+2H).

NaBH₄ can reduce RCOR (+2H).

- 27 Biophenols derived from olives are used as traditional remedies for a variety of conditions, including inflammatory states and cardiovascular diseases. Oleuropein is the most well-known compound of this family and is present in olive tree leaves. Oleuropein has the following structure:



Which statement about oleuropein is correct?

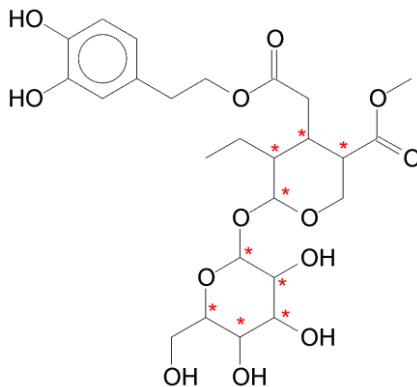
- A It does not decolourise cold alkaline KMnO_4 .
- B It reacts with Na_2CO_3 to liberate CO_2 gas.
- C A product containing 9 chiral centers is formed when 1 mole of oleuropein reacts with excess H_2 gas in the presence of platinum.
- D 6 moles of HCl are formed when 1 mole of oleuropein reacts with excess PCl_5 at room temperature.

Ans: C

Option A is incorrect: Oleuropein contains alkene functional group which can undergo mild oxidation with cold alkaline KMnO_4 .

Option B is incorrect: Na_2CO_3 reacts with carboxylic acid functional group to liberate CO_2 . However, oleuropein does not contain carboxylic acid functional group.

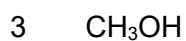
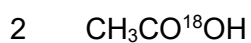
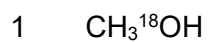
Option C is correct: Alkene functional groups undergo reduction with $\text{H}_2(\text{g})$, Pt, to give the following product, with 9 chiral centers.



Option D is incorrect: Nucleophilic substitution of $-\text{OH}$ groups in 1 mole of oleuropein to give 4 moles of HCl . Phenol does not react with PCl_5 .

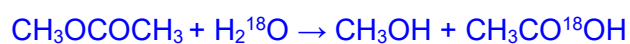
28 Methyl ethanoate, $\text{CH}_3\text{OCOCH}_3$ undergoes acidic hydrolysis in the presence of H_2^{18}O .

Which products are formed?

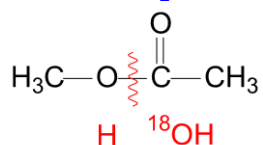


A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

Ans: C

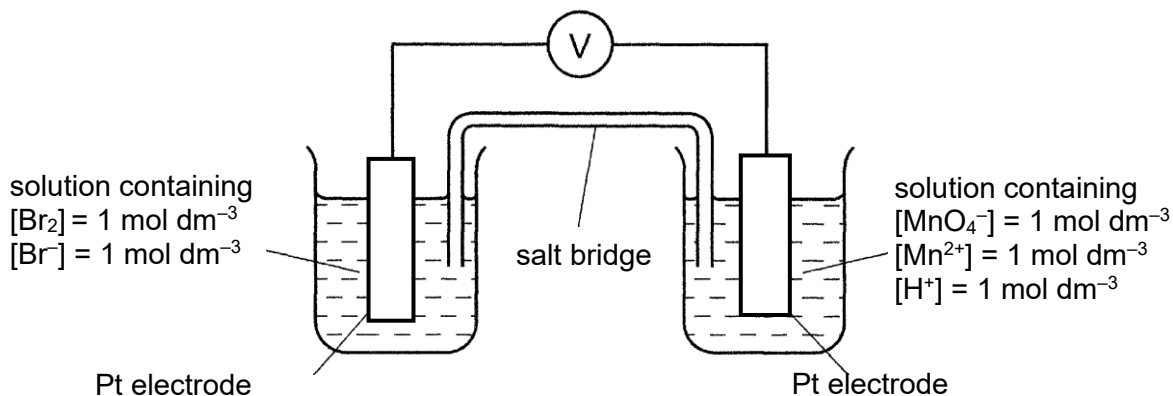


H of H_2^{18}O adds to the alcohol and the ^{18}OH of H_2^{18}O adds to the carboxylic acid in hydrolysis



29 Use of the Data Booklet is relevant to this question.

The following electrochemical cell was set up at 25 °C.



Which of the following statements are true?

- 1 When silver nitrate crystals are added to the Br_2/Br^- half cell, E_{cell} becomes less positive.
- 2 The ΔG° of the above reaction is -434 kJ mol^{-1} .
- 3 Addition of water to the $\text{MnO}_4^-/\text{Mn}^{2+}$ half-cell has no effect on the E_{cell} of the cell.

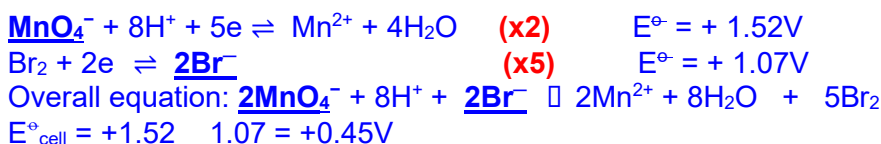
A 1 only

B 2 only

C 1 and 2 only

D 2 and 3 only

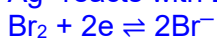
Ans: C



Option 1: **True;**

When silver nitrate crystals are added to the Br_2/Br^- half cell,

Ag^+ reacts with Br^-



$[\text{Br}^-]$ decreases, POE shifts right and E_{anode} is more positive. Hence E_{cell} becomes less positive.

Option 2: **True;**

$\Delta G^\circ = -nFE^\circ$, where $n = 10$ electrons transferred

$$\Delta G^\circ = -(10) \times 96500 \times (+0.45)$$

$$= -434 \text{ kJ mol}^{-1} \text{ (3 s.f.)}$$

Option 3: **False;**

Addition of water to the $\text{MnO}_4^-/\text{Mn}^{2+}/\text{H}^+$ will decrease the concentration of all the ions. POE shifts (left) to the side with more ions to increase the concentration, E_{cathode} more negative. E_{cell} more negative.

- 30** When crystalline potassium chromate(VI), K_2CrO_4 , was dissolved in water, a yellow solution **P** was formed. The addition of dilute sulfuric acid to **P** gave an orange solution **Q**.

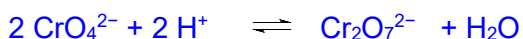
When hydrogen sulfide, H_2S , was bubbled through solution **Q**, the solution changed colour and gave a solution **R**, with a yellow solid.

Which process does **not** occur in this sequence?

- A** Ligand exchange reaction
- B** Acid-base reaction
- C** Redox reaction
- D** Precipitation reaction

Ans: A

Yellow solution **P** is $\text{CrO}_4^{2-}(\text{aq})$. When sulfuric acid is added to **P**, acid-base reaction occurs to give orange solution **Q**, $\text{Cr}_2\text{O}_7^{2-}$.



When hydrogen sulfide is bubbled into **Q**, redox reaction & precipitation occurs to give solution **R**, $\text{Cr}^{3+}(\text{aq})$ and yellow solid, S.

