



CHEMISTRY

Paper 1 Multiple Choice

9729/01

19 September 2025

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your name, civics group 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.

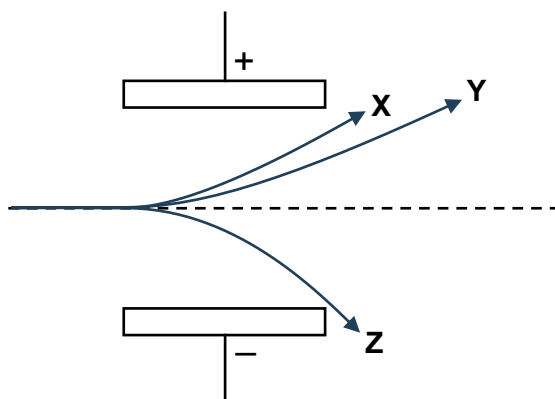
Read the instructions on the Answer Sheet very carefully.

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 question paper.

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

- 1 Three particles approach an electric field at the same speed. They are deflected as they pass through the electric field.



What could be the identities of particles **X**, **Y** and **Z**?

	X	Y	Z
A	$^{35}_{17}\text{Cl}^-$	$^{37}_{17}\text{Cl}^-$	$^{23}_{11}\text{Na}^+$
B	$^6_3\text{Li}^+$	$^7_3\text{Li}^+$	$^1_1\text{H}^-$
C	$^{37}_{17}\text{Cl}^-$	$^{35}_{17}\text{Cl}^-$	$^{23}_{11}\text{Na}^+$
D	$^7_3\text{Li}^+$	$^6_3\text{Li}^+$	$^1_1\text{H}^-$

Answer: A

Since particles **X** and **Y** are deflected to the positive terminal, they are negatively charged. Since particle **Z** is deflected to the negative terminal, it is positively charged.

Hence, **X** and **Y** must be Cl^- while **Z** must be Na^+ (either option **A** or **C** is correct).

Between particles **X** and **Y**, the larger angle of deflection of particle **X** indicates that its $\frac{e}{m}$ ratio is larger than that of **Y**. Hence, particle **X** should have a **smaller mass** number than particle **Y** since both **X** and **Y** have the same charge.

Hence, **X** is $^{35}_{17}\text{Cl}^-$ while **Y** is $^{37}_{17}\text{Cl}^-$.

2 Which of the following about calcium and copper is correct?

- A The outermost orbital of the atoms of both elements has the same shape.
- B Atom of both elements have orbitals of only 2 different shapes of various sizes.
- C Atom of both elements have the same number of electrons in the outermost shell.
- D Both elements form ions of 2+ charge with the electronic configuration of [Ar].

Answer: A

Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

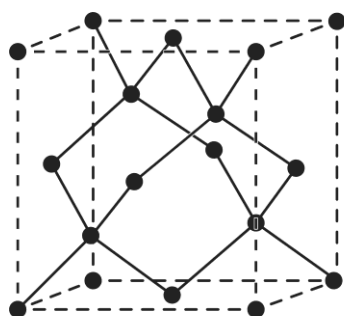
Ca²⁺: $1s^2 2s^2 2p^6 3s^2 3p^6$ or [Ar]

Cu: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

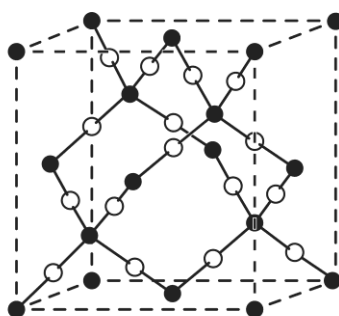
Cu²⁺: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ or [Ar] $3d^9$

- A ✓: Both atoms have 4s orbital as the outermost filled orbital. Thus, they have the same shape.
- B ×: Ca has s and p orbitals (2 different shapes), but Cu has s, p and d orbitals (3 different shapes).
- C ×: Ca has 2 electrons in the outmost shell (4s) while Cu has only 1 electron.
- D ×: Thus, the ions do not have the same electronic configuration.

3 The following diagrams show the structures of an element, one of its oxides and its halides. What could the element be?



● element



● element
○ oxygen



● element
● halogen

A aluminium

B carbon

C phosphorus

D silicon

Answer: D

Based on the first diagram on the left, the element forms 4 single bonds. Based on the last diagram on the right, the element forms 4 single bonds with the halogen atoms. Hence, it can be concluded that the element is in Group 14.

- 4 The boiling point of water (100 °C) is greater than that of HF (20 °C). Which statement is a correct explanation of the above?
- A Each hydrogen bond formed between water molecules is stronger than that formed between HF molecules.
 - B There are more atoms in a water molecule than there are in an HF molecule, resulting in stronger intermolecular forces in water.
 - C There are, on average, more hydrogen bonds between water molecules than there are between HF molecules.
 - D The water molecule has stronger permanent dipole–dipole interactions than the HF molecule.

Answer: C

- A ×: Intermolecular hydrogen bonds for HF is stronger than that of H₂O. This is because F is more electronegative than O, hence H–F bond is more polar than H–O bond, resulting in stronger hydrogen bonding.
- B ×: The electron cloud for both are comparable and hence have similar strength of intermolecular instantaneous dipole–induced dipole.
- C ✓: Each H₂O can form two hydrogen bonds; HF tends to form with fewer hydrogen bonds per molecule.
- D ×: HF has the larger dipole, but dipole–dipole differences don't outweigh water's extensive hydrogen -bond network.

- 5** For a fixed mass of an ideal gas, which of the following graphs does **not** have the same general shape as the rest?

(ρ = density of the gas; M = molar mass of gas)


- A** $\frac{p}{\rho}$ against T
- B** pV against $\frac{M}{T}$
- C** p against pT
- D** $\frac{T}{\rho}$ against V

Answer: B

A:

$$PV = nRT \Rightarrow PV = \frac{m}{M} RT$$


$$PM = \frac{m}{V} RT \Rightarrow PM = \rho RT$$

$$\frac{P}{\rho} = \frac{R}{M} T$$


The graph shows a linear relationship between $\frac{P}{\rho}$ (y-axis) and T (x-axis). The line starts at the origin (0,0) and has a constant slope labeled "grad = R/M". A dashed line indicates a point on the line.

B: $PV = nRT \Rightarrow PV = mR \frac{T}{M}$

$PV = mR \left(\frac{1}{\frac{M}{T}} \right)$




The graph shows a hyperbolic curve in the first quadrant of a coordinate system. The vertical axis is labeled 'PV' and the horizontal axis is labeled 'M/T'. The curve starts high on the PV axis and decreases as M/T increases, approaching the axes asymptotically. The origin is marked with a '0'.

C:

$$PV = nRT \Rightarrow PV = \frac{m}{M} RT$$

$$PM = \frac{m}{V} RT \Rightarrow PM = \rho RT$$

$$P = \frac{R}{M} \rho T$$


D: $PV = nRT$
 $\Rightarrow \frac{T}{P} = \frac{1}{nR}V$



The graph shows a linear relationship between T/P (y-axis) and V (x-axis). The slope is indicated as $\text{grad} = (nR)^{-1}$.

- 6 Which option correctly describes the species in terms of its behaviour as a Lewis base and as an Arrhenius acid?

	species	Lewis base	Arrhenius acid
A	HCl	no	yes
B	AlH ₃	yes	no
C	NH ₃	no	no
D	O ²⁻	yes	yes

Answer: A

- A** ✓: HCl is not a Lewis base and is an Arrhenius acid (produces H⁺/H₃O⁺ in water)
B ×: AlH₃ is a Lewis acid (electron-pair acceptor), not a Lewis base; it's also not an Arrhenius acid.
C ×: NH₃ is a Lewis base and an Arrhenius base (gives OH⁻), not an Arrhenius acid.
D ×: O²⁻ is a very strong base (Lewis and Arrhenius base), not an acid.

- 7 Use of the Data Booklet is relevant to this question.

Based on its position in the Periodic Table, which properties will indium, In, be expected to possess?

- 1 In the vapour state, the chloride dimerises to form In₂Cl₆.
- 2 Its oxide dissolves in both acids and alkalis.
- 3 Its ionic salts are typically coloured.

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

Answer: B

Option 1 ✓: Group 13 trichlorides (Al, Ga, In) are covalent and dimerise to form a general formula of M₂Cl₆.

Option 2 ✓: In₂O₃ is amphoteric (reacts with both acid and base).

Option 3 ×: In is not a transition metal, hence its salts are usually white.

- 8 Metal peroxides decompose when heated to form metal oxides and oxygen gas. Which factor contributes to solid BaO_2 being more thermally stable than solid MgO_2 ?

- A The hydration enthalpy of Mg^{2+} ion is more exothermic than that of Ba^{2+} ion.
 B The lattice energy of BaO_2 is more negative than that of MgO_2 .
 C The charge density of Ba^{2+} ion is lower than that of Mg^{2+} ion.
 D The O–O bond in O_2^{2-} is weaker than the O=O bond in O_2 .

Answer: C

A ×: Hydration enthalpy is more exothermic for Mg^{2+} than Ba^{2+} and however it does not account for the solid-state thermal stability of peroxides.

B ×: Lattice energies of Group-2 peroxides become less negative down the group ($|\text{LE}|: \text{MgO}_2 > \text{BaO}_2$). A more negative BaO_2 lattice energy is not true and wouldn't explain BaO_2 's greater stability.

C ✓: Ba^{2+} has lower charge density \rightarrow lower polarising power \rightarrow less weakening of the O–O bond in O_2^{2-} , so BaO_2 is more thermally stable (decomposes at a higher temperature) than MgO_2 .

D ×: This is a general reason peroxides decompose (forming strong O=O), but it does not explain why BaO_2 is *more stable than* MgO_2 .

- 9 F_2 reacts with BrO_z^- ions in a 2 : 1 molar ratio to form F^- and BrO_4^- ions.

What is the value of **z**?

- A 1 B 2 C 3 D 5

Answer: B



Reacting ratio between F_2 and BrO_x^- is 2:1.

\Rightarrow 1 mole of BrO_x^- loses 4 moles of electron to produce BrO_4^- .

Oxidation state of Br in $\text{BrO}_4^- = +7$

\Rightarrow Oxidation state of Br in $\text{BrO}_x^- = +3$

$$(+3) + (-2)(x) = -1$$

$$\therefore x = 2$$

- 10 Diamond is a pure form of carbon. The mass of a diamond can be measured in carats, where one carat is equivalent to 0.200 g of carbon.

How many carats is a diamond made up of 3.01×10^{23} carbon atoms?

- A 0.4 B 2.5 C 30 D 60

Answer: C

Amount of diamond = $(3.01 \times 10^{23}) / (6.02 \times 10^{23}) = \frac{1}{2} \text{ mol}$

Mass = $\frac{1}{2} \times 12 = 6 \text{ g}$

No. of carats = $6 \text{ g} / 0.200 \text{ g} = 30$

- 11 The enthalpy change of formation of potassium bromide, KBr, can be calculated using a Born-Haber cycle.

The enthalpy changes related to potassium and bromine are shown in the table.

	enthalpy change /kJ mol ⁻¹
K(s) → K(g)	+90
Br ₂ (g) → 2Br(g)	+193
K(g) → K ⁺ (g) + e ⁻	+418
Br(g) + e ⁻ → Br ⁻ (g)	-325
K ⁺ (g) + Br ⁻ (g) → KBr(s)	-678

What is the enthalpy change of formation of KBr?

- A -302 kJ mol⁻¹
 B -399 kJ mol⁻¹
 C -958 kJ mol⁻¹
 D -1054 kJ mol⁻¹

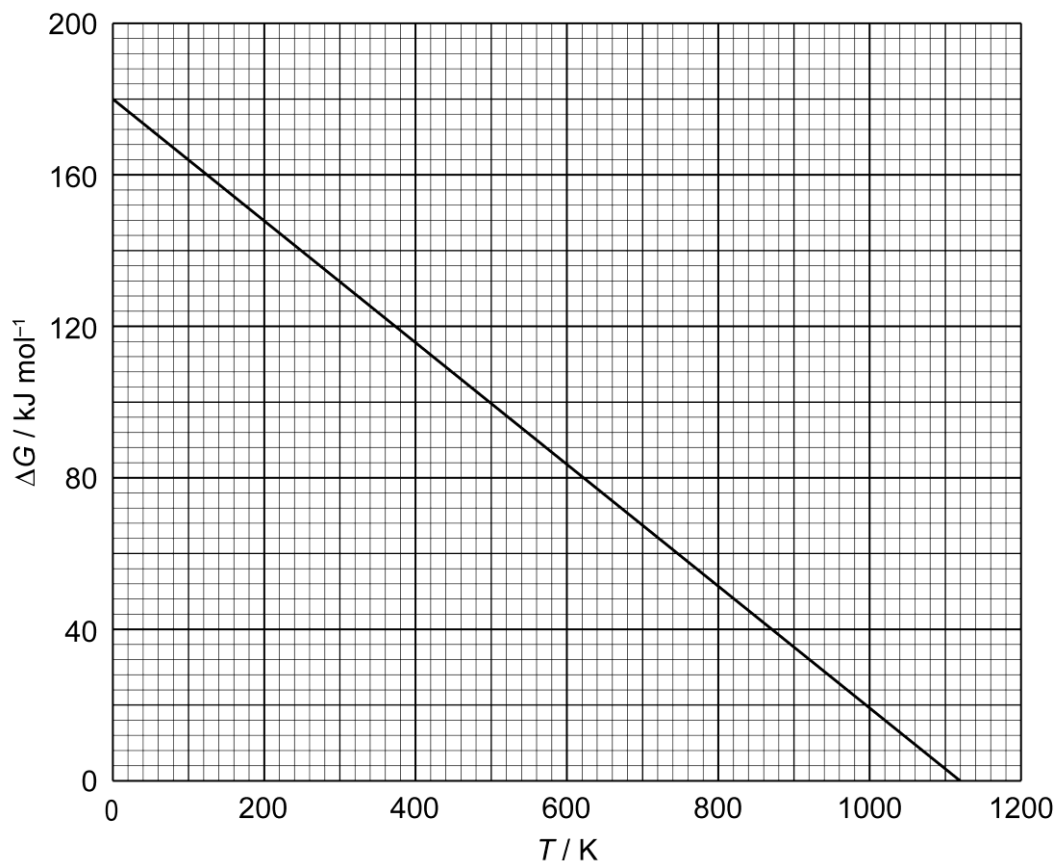
Answer: B

$\Delta H_f = \Delta H_{atom} + \text{I.E.} + \text{E.A} + \text{L.E.}$

$\Delta H_f = +90 + \frac{1}{2} (193) + 418 + (-325) + (-678) = -398.5 \text{ kJ mol}^{-1} = -399 \text{ kJ mol}^{-1} \text{ (3 s.f.)}$

- 12 When heated, magnesium carbonate decomposes to form carbon dioxide and magnesium oxide.

A graphical plot of ΔG versus T , describing the change of the Gibbs free energy of the decomposition of magnesium carbonate with respect to temperature, is shown below.



Using the information from the graph, what is the value of ΔS^\ominus for the decomposition reaction?

- A** $+6.04 \times 10^2 \text{ J mol}^{-1} \text{ K}^{-1}$
B $-6.04 \times 10^2 \text{ J mol}^{-1} \text{ K}^{-1}$
C $+1.61 \times 10^2 \text{ J mol}^{-1} \text{ K}^{-1}$
D $-1.61 \times 10^2 \text{ J mol}^{-1} \text{ K}^{-1}$

Answer: C

Using: $\Delta G = \Delta H - T\Delta S$,
 $y = c + mx$, where $c = \Delta H = 180 \text{ kJ mol}^{-1}$ and $m = -\Delta S$
 Sub in values when $\Delta G = 0$,
 $\Delta H - T\Delta S = 0$
 $\Delta H = T\Delta S$
 $180 \times 10^3 = 1120 (\Delta S)$
 $\Delta S = +1.61 \times 10^2 \text{ J mol}^{-1} \text{ K}^{-1}$

Alternatively, the gradient of the line may be calculated to obtain the answer.

- 13 Caesium-137 undergoes radioactive decay to form barium-137. This decay is a first-order reaction with a half-life of 30.2 years.

How long would it take for the molar proportion of caesium to barium to reach a ratio 1:3 from pure caesium-137?

- A** 30.2 years **B** 60.4 years **C** 90.6 years **D** 120.8 years

Answer: **B**

Amount of caesium: 100% → 50% → 25%

Amount of barium: 0% → 50% → 75%

Hence, Cs: Ba

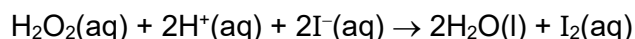
25 : 75

1 : 3

It takes **two half-lives** to attain a 1:3 ratio of Cs: Ba.

Total time taken = 2 × 30.2 = 60.4 years

- 14 The reaction of hydrogen peroxide with iodide ions in an acidic solution can be monitored by an initial rates method.



The rate equation was found to be as follows:

$$\text{rate} = k [\text{H}_2\text{O}_2][\text{I}^-]$$

What of the following mechanism correctly describes this reaction?

- A** $\text{H}_2\text{O}_2 + \text{I}^- \rightarrow \text{H}_2\text{O} + \text{IO}^-$ (slow)
 $\text{IO}^- + \text{H}^+ \rightarrow \text{HIO}$ (fast)
 $\text{HIO} + \text{H}^+ + \text{I}^- \rightarrow \text{H}_2\text{O} + \text{I}_2$ (fast)
- B** $\text{H}_2\text{O}_2 + \text{I}^- \rightarrow \text{H}_2\text{O} + \text{IO}^-$ (slow)
 $\text{H}_2\text{O}_2 + \text{IO}^- \rightarrow \text{H}_2\text{O} + \text{IO}_2^-$ (fast)
 $\text{IO}_2^- + \text{I}^- + 4\text{H}^+ \rightarrow 2\text{H}_2\text{O} + \text{I}_2$ (fast)
- C** $2\text{H}^+ + 2\text{I}^- \rightarrow 2\text{HI}$ (fast)
 $2\text{HI} + \text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{I}_2$ (slow)
- D** $\text{H}_2\text{O}_2 + \text{I}^- + \text{H}^+ \rightarrow \text{H}_2\text{O} + \text{HIO}$ (fast)
 $\text{HIO} + \text{I}^- \rightarrow \text{OH}^- + \text{I}_2$ (slow)
 $\text{OH}^- + \text{H}^+ \rightarrow \text{H}_2\text{O}$ (fast)

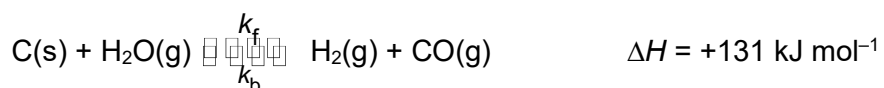
Answer: **A**

A: Mechanism matches overall equation and slow step matches rate equation.

B: Mechanism's slow step matches rate equation but does not match overall equation.

C and D: Mechanism matches overall equation but slow step does not match rate equation.

- 15 When steam is passed over white hot coke, a mixture of combustible gases is obtained.



When equilibrium has been established, which of the following correctly describes what would happen if a proposed change is made to this system?

	proposed change	value of K_c	forward rate constant, k_f	backward rate constant, k_b
A	add catalyst	no change	increase	increase
B	add more C(s)	no change	increase	no change
C	increase volume	increase	decrease	decrease
D	increase temperature	increase	increase	decrease

Answer: A

In general,

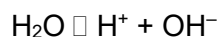
- Value of K_c is only affected by changes in **temperature**.
- Values of k_f and k_b are only affected by changes in **temperature** and **activation energies**.

For **D**, note that:

- Increase in temperature causes equilibrium position to shift to the right to favour the endothermic reaction to absorb excess heat, producing more products. As a result, value of K_c increases.
- Both rate constants, k_f and k_b , increase as the increase in temperature cause more reactants to have energy greater than or equal to activation energy, so rates of both forward and backward reactions increase.

Hence, **D** is incorrect.

16 Water dissociates into H^+ and OH^- as shown.



The pH of water decreases at higher temperatures.

Which statements are correct?

- 1 Water becomes acidic at higher temperatures.
- 2 The dissociation of water is endothermic.
- 3 The pOH decreases at higher temperatures.

A 1 only

B 3 only

C 1 and 2

D 2 and 3

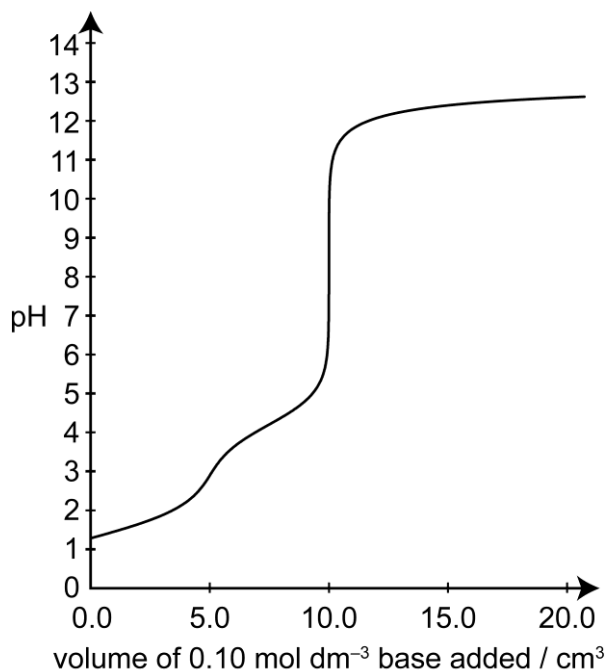
Answer: D

Option 1 ×: Water remains neutral, since both $[\text{H}^+]$ and $[\text{OH}^-]$ increases to the same extent at higher temperature, ensuring that $[\text{H}^+] = [\text{OH}^-]$.

Option 2 ✓: Dissociation of water is endothermic since bond breaking is involved.

Option 3 ✓: Since the dissociation of water is more favourable at higher temperatures, both $[\text{H}^+]$ and $[\text{OH}^-]$ increase at higher temperature. Hence, both pH and pOH would decrease at higher temperature.

- 17 The graph shows the changes in pH when excess 0.10 mol dm^{-3} base solution is added gradually to $y \text{ cm}^3$ of 0.10 mol dm^{-3} acid solution.



Which combination could have given these results?

	acid	base	y / cm^3
A	H_2SO_4	NH_3	10
B	H_2SO_4	NH_3	5
C	$(\text{COOH})_2$	KOH	10
D	$(\text{COOH})_2$	KOH	5

Answer: D

From the graph, the pH at equivalence point is more than 7. The conjugate base present is relatively strong and about to undergo hydrolysis in water. Hence, it can be inferred that it is a **weak-acid, strong-base** titration. From the options, the acid must be $(\text{COOH})_2$ and the base must be KOH .

From the graph, 10 cm^3 of KOH is required for complete neutralisation. Since the acid and base have the same concentration, 5 cm^3 of $(\text{COOH})_2$ (a dibasic acid that gives out 2 H^+ per acid molecule) will be required at the start of the titration. Hence, option **D** is correct.

18 Given the following solubility product, K_{sp} , which of the following statements is correct?

salt	K_{sp}
Ag_2SO_4	1.4×10^{-5}
PbSO_4	1.6×10^{-8}
PbI_2	7.1×10^{-9}

- A** All three K_{sp} values have the same unit.
B PbSO_4 has a lower solubility in pure water than PbI_2 .
C Solubility product of Ag_2SO_4 decreases when added to sulfuric acid.
D When solid Na_2SO_4 is added to a solution containing 0.01 mol dm^{-3} of $\text{Ag}^+(\text{aq})$ and $\text{Pb}^{2+}(\text{aq})$, Ag_2SO_4 precipitates before PbSO_4 .

Answer: B

salt	K_{sp}	Unit of K_{sp}	Solubility / mol dm^{-3}
Ag_2SO_4	1.4×10^{-5}	$\text{mol}^3 \text{ dm}^{-9}$	1.52×10^{-2}
PbSO_4	1.6×10^{-8}	$\text{mol}^2 \text{ dm}^{-6}$	1.27×10^{-4}
PbI_2	7.1×10^{-9}	$\text{mol}^3 \text{ dm}^{-9}$	1.21×10^{-3}

Thus, **A** is incorrect while **B** is correct.

C is incorrect. Solubility product does not change when temperature is held constant.

D is incorrect. Assume $0.0100 \text{ mol dm}^{-3}$ of aqueous metal ions, it will require

For Ag_2SO_4 , $K_{sp} = [\text{Ag}^+]^2[\text{SO}_4^{2-}]$

$$[\text{SO}_4^{2-}] = 1.4 \times 10^{-5} \div (0.01)^2 = 0.140 \text{ mol dm}^{-3}$$

For PbSO_4 , $K_{sp} = [\text{Pb}^{2+}][\text{SO}_4^{2-}]$

$$[\text{SO}_4^{2-}] = [1.6 \times 10^{-8} \div (0.01)]^{0.5} = 0.00126 \text{ mol dm}^{-3}$$

Thus, it will be easier to precipitate PbSO_4 .

- 19 One molecule of a non-cyclic organic compound contains only carbon atoms, hydrogen atoms and one oxygen atom. The compound is a ketone and contains a chiral carbon atom. One molecule of this compound contains x carbon atoms.

What could be the value of x ?

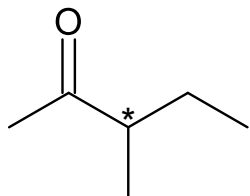
- 1 $x = 5$
- 2 $x = 6$
- 3 $x = 7$

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

Answer: C

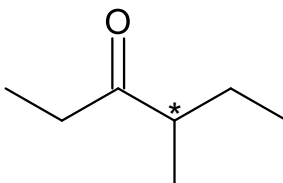
When $x = 5$, there are no molecules that contain a ketone and a chiral centre.

When $x = 6$



E.g. 3-methyl-pentan-2-one

When $x = 7$



E.g. 4-methyl-hexan-3-one

- 20 Propane undergoes free-radical substitution when mixed with chlorine and exposed to ultra-violet light.

Which compounds are possible products from this reaction?

- 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$
- 2 $\text{CH}_2\text{ClCH}_2\text{CH}_2\text{Cl}$
- 3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- 4 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

A 1, 2 and 3 **B** 1, 2 and 4 only **C** 1 and 2 only **D** 2 and 3 only

Answer: B

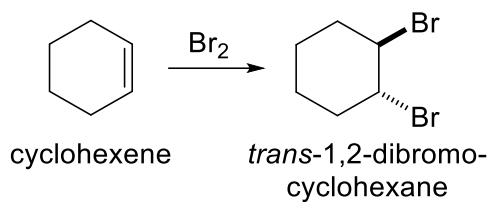
1 ✓: One or more of the H in $\text{CH}_3\text{CH}_2\text{CH}_3$ can be substituted by Cl.

2 ✓: One or more of the H in $\text{CH}_3\text{CH}_2\text{CH}_3$ can be substituted by Cl.

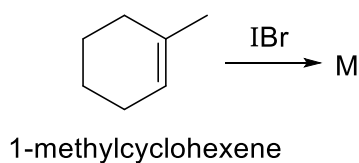
3 ✗: Requires $\text{CH}_3\text{CH}_2\text{CH}_2\cdot$ to combine with $\cdot\text{CH}_2\text{CH}_3$ which cannot be obtained from three carbon propane.

4 ✓: Two $\text{CH}_3\text{CH}_2\text{CH}_2\cdot$ radicals combine in the termination step.

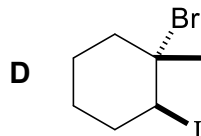
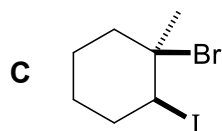
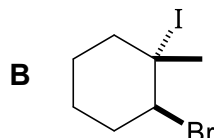
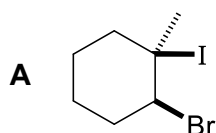
- 21 When cyclohexene reacts with bromine, only racemic *trans*-1,2-dibromocyclohexane is obtained. No *cis*-1,2-dibromocyclohexane is obtained.



1-methylcyclohexene reacts with iodine monobromide, IBr , via the same mechanism giving the Markovnikov's product, M.



Which of the following is likely to be the structure of M?



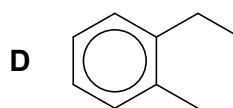
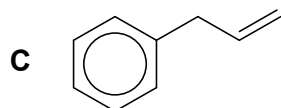
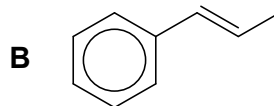
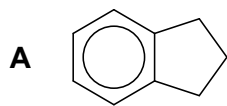
Answer: D

I and Br must add to *opposite* sides of the cyclohexene ring (*trans*).

Since **X** is the Markovnikov's product, the electron-deficient I of IBr must add to the less substituted $\text{C}=\text{C}$ carbon to form the more stable carbocation, while Br adds to the more substituted $\text{C}=\text{C}$ carbon.

- 22 Compound **Y**, C_9H_{10} , reacts upon prolonged heating with acidified concentrated $KMnO_4$ to produce $C_8H_6O_4$ as the only organic product.

What is the structural formula of **Y**?



Answer: **A**

The product $C_8H_6O_4$ with 4 oxygen atoms would highly suggest the presence of two CO_2H

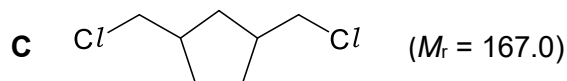
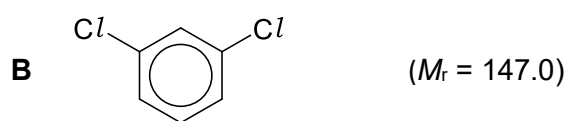
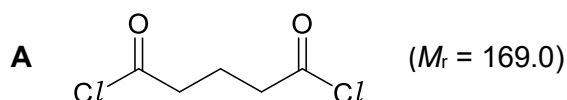
groups, *i.e.*, , resulting from the side-chain oxidation of the benzene ring.

Hence, **Y** is expected to have two alkyl "chains" attached to the benzene ring \Rightarrow **A** or **D**.

D is C_9H_{12} , which does not fit the molecular formula of **Y**.

- 23 1.00 g of each of the following compounds was heated with $NaOH(aq)$, and then dilute $HNO_3(aq)$ and $AgNO_3(aq)$ was added.

Which compound will produce the largest mass of $AgCl(s)$?



Answer: **D**

B will not react with $NaOH(aq)$. No $AgCl$ will be produced.

A and **D** will undergo hydrolysis.

- A** forms $1/169 \times 2 \times 143.3 = 1.70$ g of $AgCl$.
- D** forms $1/78.5 \times 143.3 = 1.83$ g of $AgCl$.

C will undergo nucleophilic substitution. **C** Forms $1/167 \times 2 \times 143.3 = 1.72$ g of $AgCl$.

24 Which sets of reagents and conditions can be used to form the organic product $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{CH}_2\text{NH}_2)\text{CO}_2\text{H}$ from $\text{CH}_3\text{COCH}(\text{CN})\text{CO}_2\text{H}$?

- 1 H_2 , nickel catalyst, room temperature
- 2 LiAlH_4 , dry ether as solvent, room temperature
- 3 NaBH_4 , ethanol as solvent, room temperature

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

Answer: D

There are 3 functional groups which can be reduced in the molecule – ketone, nitrile and carboxylic acid. The reducing agent can only reduce the ketone and nitrile functional group to form the desired molecule.

1 ✓ : It is able to reduce ketones and nitriles, but not carboxylic acids.

2 × : It can reduce all 3 functional groups.

3 × : It is able to only reduce ketones.

25 Propanone reacts with HCN at a slower rate compared to propanal.

Which statements are correct?

- 1 In both reactions, the carbonyl carbon reacts with a cyanide ion in the first step.
- 2 In propanone, the carbonyl carbon is more nucleophilic which repels the attacking cyanide ion.
- 3 A trace amount of NaCl is needed to catalyse the reaction.

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

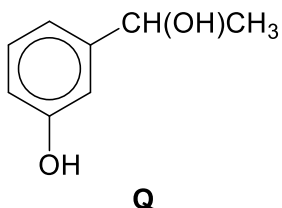
Answer: B

Option 1 ✓: The first step of nucleophilic addition involves nucleophilic attack of CN^- at the electrophilic or electron-deficient carbonyl carbon.

Option 2 ×: The carbonyl carbon in propanone is less electrophilic than that in propanal due to one additional electron-donating alkyl group, hence less susceptible to nucleophilic attack by CN^-

Option 3 ×: The reaction is catalysed by addition of a trace amount of NaCN, which can be formed *in situ* by adding a trace amount of NaOH ($\text{NaOH} + \text{HCN} \rightarrow \text{NaCN} + \text{H}_2\text{O}$)

- 26 How many moles of $\text{H}_2(\text{g})$ is produced when 1 mole of **Q** reacts with $\text{Na}(\text{s})$ and how many moles of $\text{CO}_2(\text{g})$ is produced when 1 mole of **Q** reacts with $\text{Na}_2\text{CO}_3(\text{aq})$?



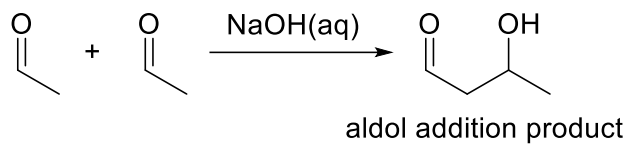
	$\text{H}_2(\text{g})$ produced with $\text{Na}(\text{s})$	$\text{CO}_2(\text{g})$ produced with $\text{Na}_2\text{CO}_3(\text{aq})$
A	0	1
B	1	2
C	1	0
D	2	1

Answer: C

In molecule **Q**, there is one phenolic -OH group and one aliphatic -OH group. Both -OH groups will react with $\text{Na}(\text{s})$ to form $\frac{1}{2} \text{H}_2(\text{g})$. Hence, the total amount of $\text{H}_2(\text{g})$ formed is 1 mole.

The aliphatic -OH group is a weak acid that is not able to undergo acid-base reaction with $\text{Na}_2\text{CO}_3(\text{aq})$. For the phenolic -OH group, while it reacts with $\text{Na}_2\text{CO}_3(\text{aq})$, only HCO_3^- is formed as the product and not CO_2 . Hence, the total amount of $\text{CO}_2(\text{g})$ formed is 0 mole.

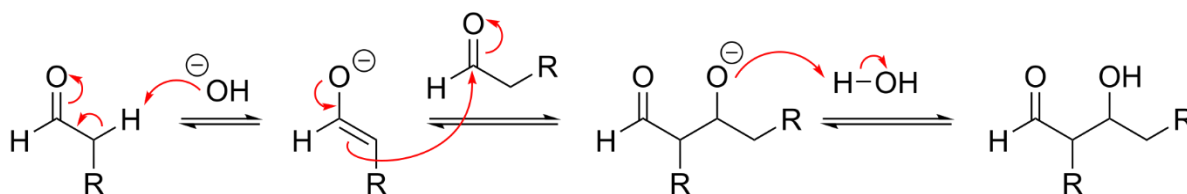
- 27 Aldol addition products are formed when a small amount of NaOH(aq) is added to carbonyl compounds at room temperature.



Which product is **not** formed when a small amount of NaOH(aq) is added to an equimolar mixture of propanone and propanal?

- A**
- B**
- C**
- D**

Answer: D



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

An electrochemical cell is set up using a $\text{Zn}^{2+}(\text{aq})|\text{Zn}(\text{s})$ half-cell and a $\text{MnO}_4^{-}(\text{aq})|\text{Mn}^{2+}(\text{aq})$ half-cell in acidic solution.

Which of the following gives a correct effect on the E_{cell} when each of the changes is made to the corresponding half-cell separately?

	change	half-cell	effect on E_{cell}
A	addition of water	$\text{MnO}_4^{-}(\text{aq}) \text{Mn}^{2+}(\text{aq})$	less positive
B	addition of $\text{Mn}(\text{NO}_3)_2(\text{s})$	$\text{MnO}_4^{-}(\text{aq}) \text{Mn}^{2+}(\text{aq})$	no change
C	addition of $\text{Zn}(\text{NO}_3)_2(\text{s})$	$\text{Zn}^{2+}(\text{aq}) \text{Zn}(\text{s})$	more positive
D	addition of $\text{Na}_2\text{CO}_3(\text{s})$	$\text{Zn}^{2+}(\text{aq}) \text{Zn}(\text{s})$	no change

Answer: A

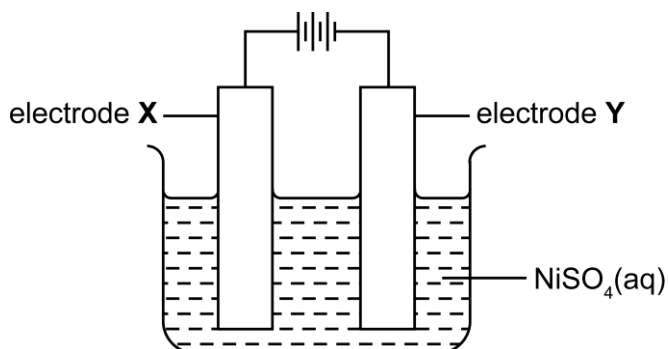
A: Adding water to $\text{MnO}_4^{-}/\text{Mn}^{2+}$ half-cell will result in the position of equilibrium to shift to the left as there are more concentration terms and making the E for that half-cell less positive. This makes E_{cell} less positive.

B: Increasing $[\text{Mn}^{2+}]$ will result in the position of equilibrium to shift to the left for $\text{MnO}_4^{-}/\text{Mn}^{2+}$ half-cell and making the E for that half-cell less positive. This makes E_{cell} less positive.

C: More Zn^{2+} favours reduction of Zn^{2+} , E of Zn^{2+}/Zn half-cell becomes more positive. E_{cell} becomes less positive.

D: Adding Na_2CO_3 to Zn^{2+}/Zn half-cell will result in the formation of $\text{ZnCO}_3(\text{s})$, resulting in the position of equilibrium to shift to the left as it only lowers the $[\text{Zn}^{2+}]$ and making the E for that half-cell less positive. This makes E_{cell} more positive.

29 In an experiment, a cell was set up to obtain pure nickel from a nickel-silver alloy.



Which of the following statements is correct?

- A Electrode Y is the nickel-silver alloy.
- B The concentration of the electrolyte must be 1 mol dm^{-3} .
- C The electrolyte may be replaced with sodium sulfate solution.
- D The mass of the cathode changes by the same mass as the anode.

Answer: C

- A Electrode X is the nickel-silver alloy as the cathode (electrode Y) will be where the pure metal is formed.
- B The concentration of the electrolyte may not be 1 mol dm^{-3} since it may not take place at standard conditions
- C The purification will not be affected by the change of electrolyte to Na_2SO_4 since both Na^+ and SO_4^{2-} are not likely to undergo redox reaction based on their standard electrode potential.
- D The mass of the cathode will not change by the same mass as the anode since the silver at the anode will fall off as sludge.

30 Which of the following about period 4 transition elements is correct?

- A** The atomic radius decreases across the period.
- B** First ionisation energy remains relatively constant across the period.
- C** Period 4 transition elements have lower melting point than s block elements.
- D** The densities of period 4 transition elements are comparable to those of s block elements.

Answer: B

A: atomic radius remains relatively constant as nuclear charge increases, shielding effect also increase (electrons are added to inner 3d orbitals). The increase in nuclear charge and shielding effect almost cancels each other out. Hence, effective nuclear charge does not increase significantly to result in a significant trend.

C: Higher melting point. In transition elements, the sea of delocalised electrons is contributed by both 3d and 4s electrons, resulting in stronger metallic bonds compared to s block elements.

D: Transition elements are more dense than s block elements.