YISHUN INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME	**SUGGESTED SOLUTIONS**		
CG		INDEX NO	

CHEMISTRY 9729/01

Paper 1 Multiple Choice **13 September 2024**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name and class 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.

This document consists of **15** printed pages and **1** blank page.

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1 A sample of calcium contains three naturally occurring isotopes, ^{40}Ca, ^{42}Ca and ^{44}Ca.

The sample is made up of 96.64% of ^{40}Ca and the relative atomic mass of calcium in this sample is 40.11.

What is the percentage of the isotope ^{42}Ca in the sample?

A 0.44% **B** 0.67% **C** 1.22% **D** 2.09%

Answer: **C**

^{40}Ca	96.64%
^{42}Ca	x%
^{44}Ca	(3.36 – x)%

$$40.11 = \frac{(40.0 \times 96.64) + (42.0x) + [(3.36 - x) \times 44.0]}{100}$$

x = 1.22%

2 Aluminium chloride dimerises to give Al_2Cl_6.

Which statement about aluminium chloride and its dimer is correct?

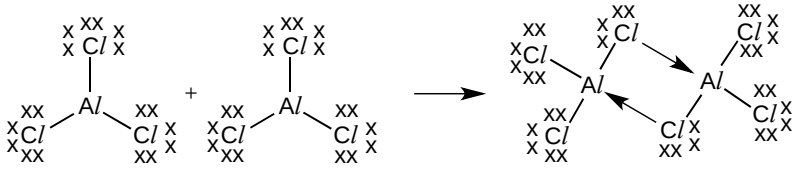
A $AlCl_3$ has a high melting and boiling point due to strong electrostatic forces of attraction between Al^{3+} and Cl^-.

B Each aluminium atom is surrounded by four chlorine atoms in the dimer, Al_2Cl_6.

C Some of the bond angles decrease while some remains the same when $AlCl_3$ dimerises to form Al_2Cl_6.

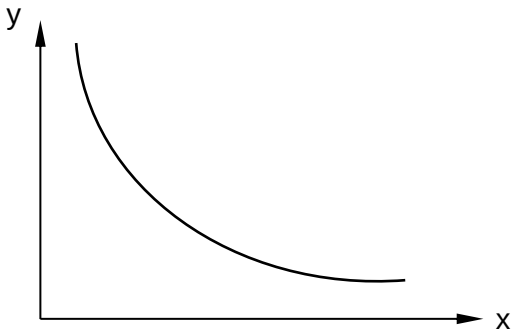
D The geometry around each aluminium atom in Al_2Cl_6 is trigonal planar.

Answer: **B**



A: Aluminium chloride has simple molecular structure due to the high polarising powe of Al^{3+} and the polarisability of the Cl^- ions.
B: From the above diagram, each aluminium atom is surrounded by 4 chlorine atoms.
C and D: As seen in the diagram, the bond angles will all decrease when aluminium chloride dimerises as the shape around the central aluminium atom changes from trigonal planar (120°) to tetrahedral (approximately 109.5°.)

3 The graph shows the behaviour of one mole of an ideal gas.



Which of the following will produce the graph shown?

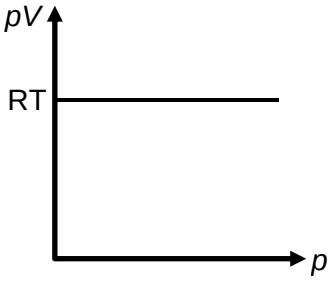
	y-axis	x-axis	condition
A	pV	p	at constant temperature
B	p	V	at constant temperature
C	p	1/V	at constant temperature
D	T (in K)	V	at constant pressure

Answer: **B**

For option **A**:

If temperature is constant for 1 mol of an ideal gas,

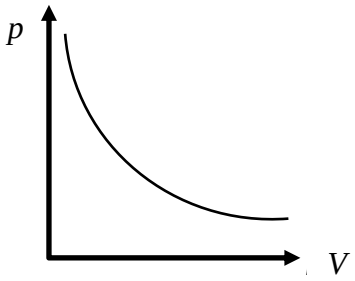
- pV = nRT = constant
- The pV against p plot will be a horizontal line that cuts the y-axis at a value of RT.



For Option **B**:

If temperature is constant for 1 mol of an ideal gas,

- $pV = nRT \Rightarrow p = \frac{nRT}{V}$
- The p against V plot will be a curve as shown.



For option **C**:

If temperature is constant for 1 mol of an ideal gas,

- $pV = nRT \Rightarrow p = \frac{nRT}{V}$
- The p against $\frac{1}{V}$ will be a straight line that passes through the origin.

For option **D:**

If pressure is constant for 1 mol of an ideal gas,

- $pV = nRT \Rightarrow T = \frac{p}{nR} V$
- The T against V will be a straight line that passes through the origin.

4 Sodium, magnesium, aluminium, silicon and phosphorus are all elements in Period 3 of the Periodic Table.

Three statements about the oxides and chlorides of these elements are given.

Which statements are correct?

1 The ionically bonded oxides all react with dilute hydrochloric acid.

2 All metal chlorides produced neutral solutions when added to water.

3 The two most electronegative elements both form covalently bonded chlorides.

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

Answer: **C**

1 Correct.
Ionic oxides are basic in nature and hence will react with dilute hydrochloric acid.

2 Incorrect.
Only NaC*l* gives a neutral solution. MgCl_2 and A*l*Cl_3 give an acidic solution.

3 Correct.
The two most electronegative elements are Si and P. The chlorides of both elements are covalent chlorides.

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5 The table shows the trend in the stated properties from magnesium to barium in Group 2.

Which row is correct?

	decomposition temperature of the carbonate	reducing power
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

Answer: A

The thermal stabilities of the Group 2 carbonates increase down the group.
This is because going down the group, while the charge of the cations (+2) remains the same, the size of cation (or ionic radius) increases. This causes the charge density and hence the polarising power of the cations to decrease. As such, the cations are less able to polarise the electron cloud of the carbonate ion and the C-O covalent bonds within the carbonate ion are weakened to a smaller extent. Consequently, more energy and a higher temperature is required for the decomposition of the Group 2 carbonates.

The reducing power of Group 2 elements increases down the group.

	$E^{\ominus}$ / V
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	–2.38
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	–2.87
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	–2.91

Down Group 2, $E^{\ominus}$ values become more negative. Equilibrium position lies more to the left, hence the higher tendency for oxidation process.

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6 *Use of the Data Booklet is relevant to this question.*

The element astatine, At, is in Group 17 of the Periodic Table.

1 It is a coloured solid at room temperature.

2 Its hydride is thermally more stable than the hydride of iodine.

3 It is more electronegative than iodine.

Which statements about At will be true?

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

Answer: **D**

Astatine is below iodine in Group 7 of the Periodic Table. Since iodine is a black solid, At is expected to be a coloured solid.

The hydride of astatine, HAt, is expected to have a weaker H-At bond than H-I bond. Hence the H-At bond can be overcome by heat more easily and HAt is not thermally stable.

Electronegativity decreases down the group and thus At is less electronegative than iodine.

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7 When 30 cm^3 of a hydrocarbon was burnt in excess oxygen, there was a contraction of 105 cm^3. On treating the cooled resulting mixture with excess potassium hydroxide, a further contraction of 150 cm^3 occurred. All volumes were measured at r.t.p.

What is the formula of the hydrocarbon?

A C_3H_6 **B** C_3H_8 **C** C_5H_{10} **D** C_5H_{12}

Answer: **D**

First contraction:
volume of C_xH_y reacted + volume of O_2 reacted – volume of CO_2 formed = 105 cm^3
volume of O_2 reacted = 105 – 30 + 150 = 225 cm^3

Second contraction: volume of CO_2 produced = 150 cm^3

	C_xH_y +	$(x + \frac{y}{4})\ O_2$	$\longrightarrow\ xCO_2$	+ $(\frac{y}{2})\ H_2O$
volume of gas used or formed / cm^3	30	225	150	-
volume ratio	1	7.5	5	
stoichiometry mole ratio	1	$x + \frac{y}{4}$	x	$\frac{y}{2}$

x = 5
$x + \frac{y}{4} = 7.5$
Hence y = 10
Formula of hydrocarbon: C_5H_{10}

8 Iron metal and VO_2^+ were reacted together in a 1 : 1 ratio until all the iron metal was oxidised to Fe^{2+} ions.

What is the oxidation state of vanadium in the product?

A +2 **B** +3 **C** +4 **D** +5

Answer: **B**

[O]: $Fe + 2e^- \longrightarrow Fe^{2+}$
Mole ratio: Fe : e^- : VO_2^+ is 1 : 2 : 1
Hence, 1 mol of VO_2^+ gained 2 mol of electrons, which means that the change in oxidation number of vanadium in VO_2^+ is −2.
Oxidation state of vanadium in VO_2^+ = −2(−2) + 1 = +5
Final oxidation state of vanadium after reaction with Fe = +5 − 2 = +3

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9 *Use of the Data Booklet is relevant to this question.*

Butanal can be synthesised from propene, C_3H_6.

$$CH_3CH{=}CH_2(g) + CO(g) + H_2(g) \rightleftharpoons CH_3CH_2CH_2CHO(g)$$

What is the value of the enthalpy change of the reaction?

A +47 kJ mol^{-1}

B –47 kJ mol^{-1}

C +137 kJ mol^{-1}

D –137 kJ mol^{-1}

Answer: **D**

Bonds broken = BE(H-H) + BE(C≡O) + BE(C=C) = 436 + 1077 + 610 = 2123 kJ mol^{-1}

Bonds formed = 2BE(C-H) + 2BE(C-C) + BE(C=O) = 2(–410) + 2(–350) + (–740) = –2260 kJ mol^{-1}

ΔH = energy required for breaking bonds + energy evolved when bonds are formed
= 2123 + (–2260) = **–137 kJ mol^{-1}**

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10 Ammonia gas and hydrogen chloride gas react to form ammonium chloride.

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s) \qquad \Delta H^{\ominus} = -176 \text{ kJ mol}^{-1}$$

The magnitude of standard entropy change of this reaction is 284 J K^{-1} mol^{-1}.

Which statements are correct?

1 $\Delta G^{\ominus}$ is –261 kJ mol^{-1} for the above reaction.

2 There is a decrease in disorder as the particles in NH_4Cl are held close to each other in fixed positions.

3 The reaction becomes non-spontaneous at high temperature.

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

Answer: **D**

There is a decrease in number of moles of gaseous particles, less ways of arranging the particles, resulting in a decrease in disorder. Hence, ΔS is negative.

1 Incorrect.
Number of moles of gas decreases.
$\Delta S^{\ominus} = -284 \text{ J K}^{-1} \text{ mol}^{-1}$
$\Delta G^{\ominus} = -176 - 298 \times (-0.284) = -91.4 \text{ kJ mol}^{-1}$.

2 Correct.
The formation of solid NH_4Cl where the molecules are held in fixed positions, compared to the gaseous reactants would result in a decrease in disorder.

3 Correct.
$\Delta G = \Delta H - T\Delta S$
Since $\Delta H < 0$ and $\Delta S < 0$, when temperature increases, $|-T\Delta S| > |\Delta H|$. This results in $\Delta G > 0$. Hence, reaction becomes non-spontaneous at high temperature.

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11 A first-order decomposition reaction is shown below.

$$2XY(g) \rightarrow X_2Y_2(g)$$

The half-life of the reaction was found to be 3.46 s.

What is the time taken for $X_2Y_2(g)$ to reach 99% of its final concentration?

A 21.0 s **B** 22.0 s **C** 23.0 s **D** 24.0 s

Answer: **C**

When X_2Y_2 reaches 99% of its final concentration, 1% of XY is left to react.

$$\frac{\text{final concentration of reactant}}{\text{initial concentration of reactant}} = \left(\frac{1}{2}\right)^n$$

$$\frac{0.01}{1} = \left(\frac{1}{2}\right)^n$$

$$n = \ln 0.01 \div \ln\left(\frac{1}{2}\right) \approx 6.644$$

Time taken = 6.644 × 3.46 = 23.0 s

12 Nitric oxide, NO, reacts with oxygen to form nitrogen dioxide.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The reaction is thought to involve the following steps.

$$NO + O_2 \rightleftharpoons NO_3 \quad \text{(fast)}$$
$$NO_3 + NO \rightarrow NO_2 + NO_2 \quad \text{(slow)}$$

Which conclusions can be drawn from this information?

1 O_2 is acting as a catalyst.

2 NO_3 is an intermediate in this reaction.

3 The reaction is first order with respect to NO.

4 The reaction is first order with respect to O_2.

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

Answer: **C**

1 Incorrect.
O_2 is reacted but not regenerated. It is a reactant.

2 Correct.
NO_3 is produced in step 1 and reacted in step 2.

3 Incorrect.
Based on the rate-determining step, rate = $k[NO_3][NO]$
Since NO_3 is an intermediate, it should not be in the rate equation.
$k_f[NO][O_2] = k_b[NO_3]$
$[NO_3] = \frac{k_f}{k_b}[NO][O_2]$
Substitute $[NO_3] = \frac{k_f}{k_b}[NO][O_2]$ into rate equation,
rate = $k'[NO]^2[O_2]$ where $k' = (k \times \frac{k_f}{k_b})$
Therefore, reaction is second order with respect to [NO].

4 Correct.
rate = $k'[NO]^2[O_2]$ where $k' = (k \times \frac{k_f}{k_b})$
Therefore, reaction is first order with respect to $[O_2]$.

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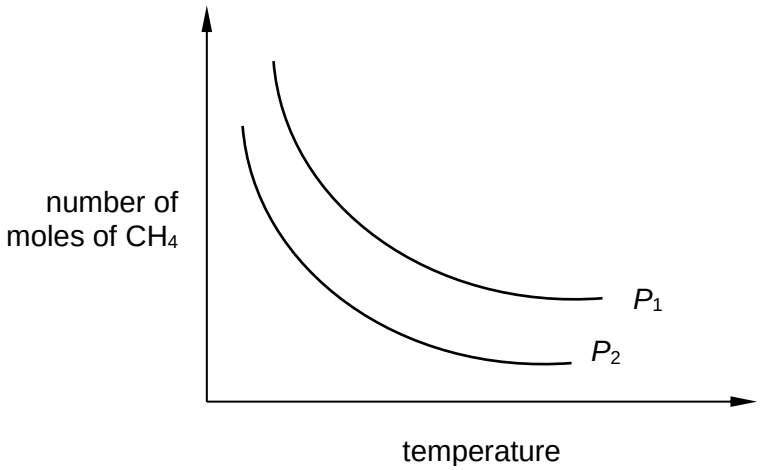
13 The graph below shows how the number of moles of CH_4 varies with temperature at two different pressures of P_1 and P_2 respectively for the following equilibrium.

$$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$$



Which statements are correct?

1 The forward reaction is exothermic.

2 The magnitude of P_1 is greater than the magnitude of P_2.

3 Adding catalyst increases the amount of CH_4 formed.

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

Answer: **C**

1 Correct.
By *Le Chatelier's* Principle, when temperature increases, position of given equilibrium will shift to favor the endothermic reaction as so to absorb heat and decrease the temperature.
From the graph, amount of CH_4 decrease with increasing temperature. This means that backward reaction is favored with increasing temperature.
Hence, backward reaction is endothermic and forward reaction is exothermic.

2 Correct.
By Le Chatelier's Principle, when pressure increases, position of given equilibrium will shift to the right to favor the reaction forming fewer gaseous particles as so to decrease the pressure.
From the graph, at each temperature, there are more CH_4 (product) at P_1.
Hence, P_1 should be higher pressure.

3 Incorrect.
Using catalyst increases the rate of forward and backward reaction equally, allowing the equilibrium to be reached faster but does not change the equilibrium concentration of the mixtures.

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14 12.50 cm^3 of 0.100 mol dm^{-3} sodium hydroxide was added to 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid.

What is the pH of the resulting solution?

A 1.00

B 1.48

C 2.60

D 2.90

Answer: **B**

$NaOH + HCl \rightarrow NaCl + H_2O$
Amount of NaOH = 0.100 × 0.0125 = 0.00125 mol
Amount of HCl = 0.100 × 0.025 = 0.00250 mol
HCl is in excess
Amount of HCl left = 0.00250 – 0.00125 = 0.00125 mol
[HCl] = 0.00125 ÷ (0.0125 + 0.025) = 0.033333 mol dm^{-3}
pH = –log $[H^+]$ = –log [HCl] = –log (0.033333) = 1.4771 = **1.48**

15 What is a suitable indicator for the titration between 0.10 mol dm^{-3} nitric acid and 0.10 mol dm^{-3} aqueous ammonia?

A bromothymol blue (pH range 6.0–7.6)

B methyl orange (pH range 3.1–4.4)

C phenolphthalein (pH range 8.3–10.0)

D There is no suitable indicator

Answer: **B**

A suitable indicator is the one which shows colour change in a pH range that covers the pH of the solution at equivalence point.
At equivalence point for a strong acid-weak base titration, the conjugate acid NH_4^+ undergoes hydrolysis in water to give H_3O^+

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

Hence, pH at equivalence point is < 7 and methyl orange would be suitable indicator.

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16 The ionic product of water, K_w, is affected by temperature.

temperature / °C	K_w / $mol^2\,dm^{-6}$
0	1.0×10^{-15}
50	5.5×10^{-14}

Which statement describes what happens as the temperature of water is increased from 0 °C to 50 °C?

A pH of water increases and $[H^+] = [OH^-]$

B pH of water increases and $[H^+] < [OH^-]$

C pH of water decreases and $[H^+] > [OH^-]$

D pH of water decreases and $[H^+] = [OH^-]$

Answer: D

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$
$K_w = [H_3O^+][OH^-]$

Based on the given table, as temperature increases, K_w increases. This means that $[H_3O^+]$ and $[OH^-]$ both increases.
pH of water will decrease as $[H^+]$ increases but $[H^+] = [OH^-]$ (ie. water is neutral at all temperature).

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17 An aqueous solution containing both potassium chloride and potassium iodide is treated with an excess of aqueous silver nitrate.

The precipitate formed is filtered off and washed with deionised water. The precipitate is then shaken with aqueous ammonia and filtered off again.

Which ion is present in the final filtrate?

A chloride

B iodide

C potassium

D silver

Answer: **A**

When treated with an excess of $AgNO_3$, both $AgCl$ and AgI will be precipitated.
When both precipitates are shaken with $NH_3(aq)$, only $AgCl$ will dissolved.

$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$
$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq)$

18 Which molecule contains a total of two sp hybridised atoms?

A $H_2C{=}CH{-}CH{=}CH_2$

B $HC{\equiv}C{-}C{\equiv}CH$

C $H_2C{=}CH_2$

D $HC{\equiv}CCH_3$

Answer: **D**

sp hybrisided carbon atom forms 1 σ bond and 2 π bonds.

$HC{\equiv}CCH_3$	$H_2C{=}CH_2$	$HC{\equiv}C{-}C{\equiv}CH$	$H_2C{=}CH{-}CH{=}CH_2$
2 sp hybrisided C	0 sp hybrisided C	4 sp hybrisided C	0 sp hybrisided C

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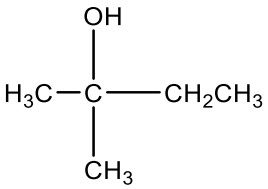
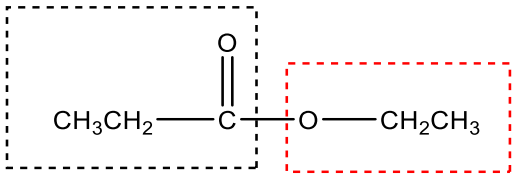
19 Which row is correct?

	2-methylbutan-2-ol	$C_2H_5CO_2C_2H_5$
A	secondary alcohol	propyl ethanoate
B	secondary alcohol	ethyl propanoate
C	tertiary alcohol	propyl ethanoate
D	tertiary alcohol	ethyl propanoate

Answer: **D**

2-methylbutan-2-ol	$C_2H_5CO_2C_2H_5$
 It is a tertiary alcohol since the C bonded to the -OH group is bonded to 3 alkyl groups.	 propanoate ethyl

20 A straight chain organic compound has a molecular formula of C_4H_5NO. It contains a nitrile, −CN, functional group.

Which other functional groups could be present?

1 aldehyde

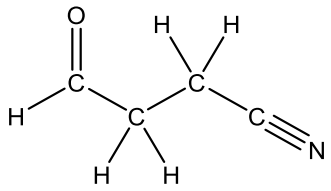
2 alkene

3 amide

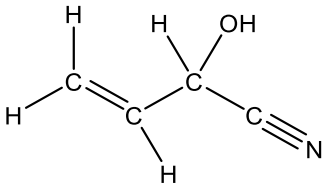
A 1, 2 and 3 **B** 1 and 2 only **C** 1 only **D** 3 only

Answer: **B**

Since the N atom has been used to form nitrile, it is not possible to form another amide functional group (since there is no more N atom).



aldehyde present



alkene present

21 Which reaction is a termination step in the chain reaction between chlorine and methane, in the presence of ultraviolet light?

A $\bullet CH_3 + \bullet CH_3 \rightarrow CH_3CH_3$

B $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

C $\bullet CH_3 + H\bullet \rightarrow CH_4$

D $H\bullet + Cl\bullet \rightarrow HCl$

Answer: **A**

- A termination step involves the homolytic bond-forming between 2 radicals. Hence option B is wrong. (Option B is a propagation step).
- In the free radical substitution mechanism, a H● is never formed. Hence option C and D are wrong.

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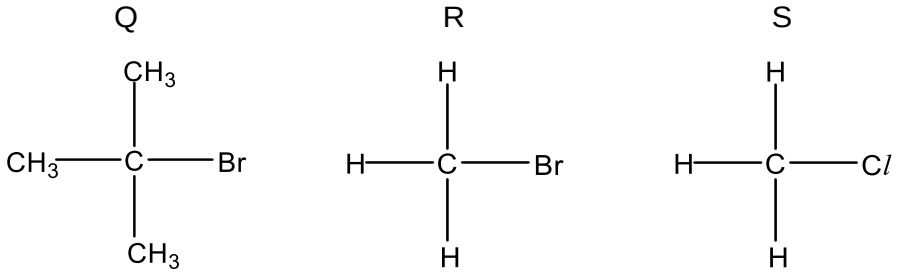
22 The diagram shows the structure of three halogenoalkanes.



Q, R and S can be hydrolysed.

Which row is correct?

	relative speed of hydrolysis		mechanism of hydrolysis	
	R	S	Q	R
A	fast	slow	S_N1	S_N2
B	fast	slow	S_N2	S_N1
C	slow	fast	S_N1	S_N2
D	slow	fast	S_N2	S_N1

Answer: **A**

R is a bromoalkane undergoes hydrolysis at a faster rate than S, a chloroalkane, as the C–Br bond is weaker than the C–C*l* bond and lesser energy is required to break it.
Q is a tertiary halogenoalkane and undergoes S_N1 mechanism. R is a primary halogenoalkane and undergoes S_N2 mechanism.

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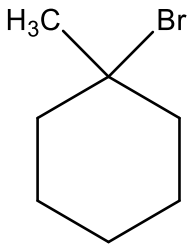
23 Compound T, $C_7H_{13}Br$, reacts with hot alcoholic NaOH to produce two compounds, U and V.

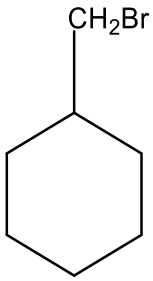
On reaction with Br_2, U gives a product, $C_7H_{12}Br_2$, which exists as a mixture of four enantiomers.
On reaction with Br_2, V gives a product, $C_7H_{12}Br_2$, which is non-chiral.

What could T be?

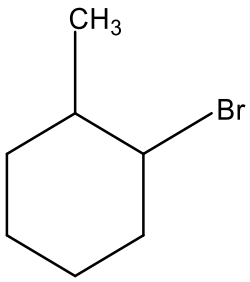
A



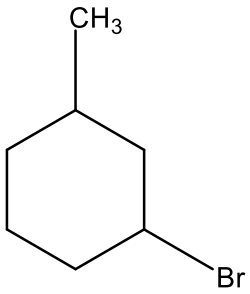
B



C

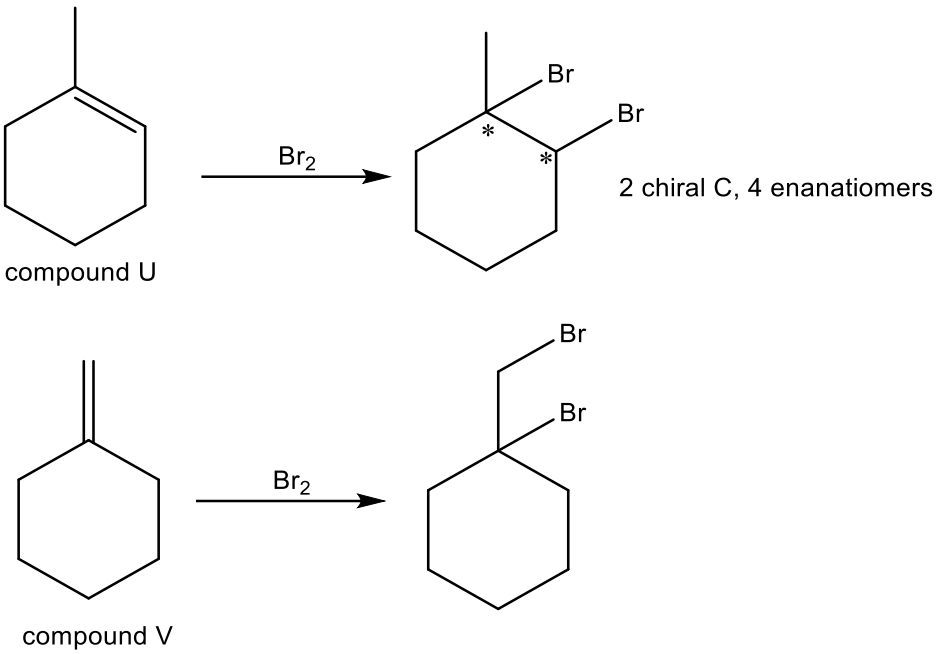


D



Answer: **A**

Molecule in **A** undergoes elimination with alcoholic NaOH to give compounds U and V as shown which subsequently undergo electrophilic addition with Br_2.



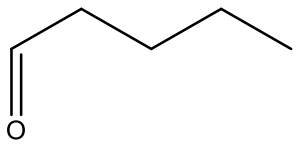
24 Compound W has molecular formula $C_5H_{10}O$.
W gives an orange precipitate with 2,4-dinitrophenylhydrazine and gives a silver mirror with Tollens' reagent.

How many isomers, including stereoisomers, does W have?

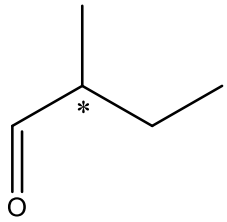
A 4 **B** 5 **C** 6 **D** 7

Answer: **B**

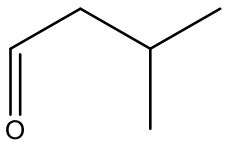
Compound W is an aldehyde since it undergoes condensation with 2,4-DNPH and undergoes oxidation with Tollens' reagent.



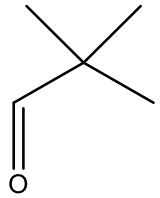
pentanal



2-methylbutanal
(exists as a pair
of enantiomers)



3-methylbutanal



2,2-dimethypropanal

25 Which row describes the order of decreasing acid strengths of the four compounds?

A ethanoic acid > fluoroethanoic acid > phenol > ethanol

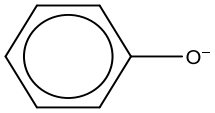
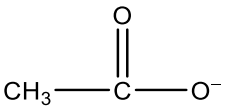
B fluoroethanoic acid > ethanoic acid > phenol > ethanol

C ethanol > phenol > fluoroethanoic acid > ethanoic acid

D fluoroethanoic acid > ethanoic acid > ethanol > phenol

Answer: **B**

The relative acidities of alcohol, phenol and carboxylic acid can be explained by comparing the stability of their conjugate base.

	ethanol	phenol	ethanoic acid
conjugate base	CH_3CH_2-O^- ethoxide ion	 phenoxide ion	 ethanoate ion
stability of conjugate base	destabilised	stabilised	stabilised
factor affecting stability of conjugate base	presence of electron−donating ethyl groups, $-CH_2CH_3$, intensified the negative charge on the oxygen atom	the negative charge on the O atom is partially delocalised into the benzene ring	the negative charge on the O atom is completely delocalised between the two electronegative oxygen atoms(*)
acid strength	weaker than phenol	stronger than ethanol but weaker than ethanoic acid	stronger than phenol

Fluoroethanoic acid is a stronger acid than ethanoic acid as F is an electron withdrawing group and further disperses the negative charge on the O atom in $FCH_2CO_2^-$. Hence $FCH_2CO_2^-$ is more stable than $CH_3CO_2^-$.

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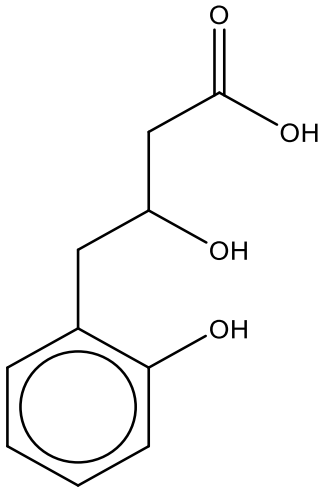
26 The structure of compound X is shown.



X

One mole of compound X reacts with two moles of substance Y.

What could be substance Y?

1 anhydrous PCl_5

2 sodium

3 sodium carbonate

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

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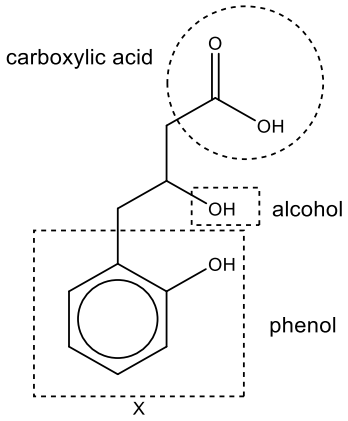
Answer: **A**



1. Only the carboxylic acid and alcohol react with anhydrous PCl_5.Phenol does not undergo substitution due to the strong C–O bond.
   $ROH + PCl_5 \rightarrow RCl + POCl_3 + HCl$
   $RCO_2H + PCl_5 \rightarrow RCOCl + POCl_3 + HCl$

2. Sodium reacts with all three functional groups with –OH groups via redox / acid-metal reaction
   $ROH + Na \rightarrow RONa + ½H_2$
   $RCO_2H + Na \rightarrow RCO_2Na + ½H_2$
   $C_6H_5OH + Na \rightarrow C_6H_5ONa + ½H_2$

3. Na_2CO_3 reacts only with carboxylic acid via acid-base reaction.
   $RCO_2H + ½Na_2CO_3 \rightarrow RCO_2Na + ½CO_2 + ½H_2O$

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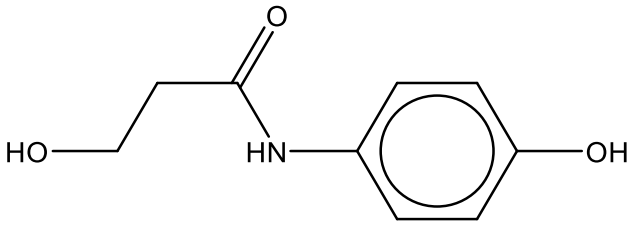
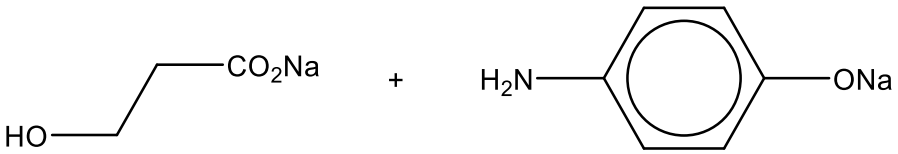
27 Compound Z has been used as a painkiller.



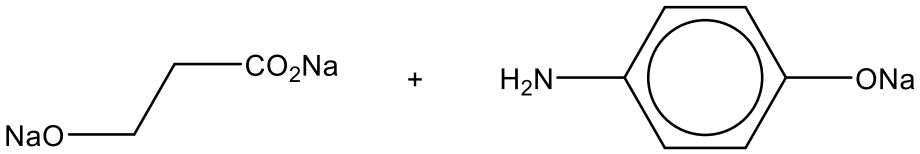
Z

What are the products when Z is hydrolysed by heating with NaOH(aq)?

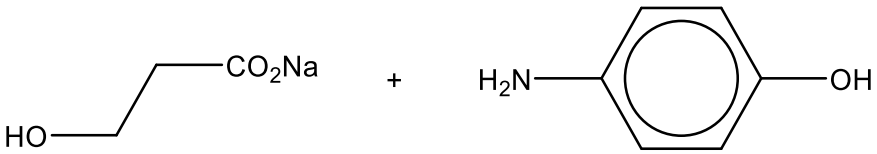
A



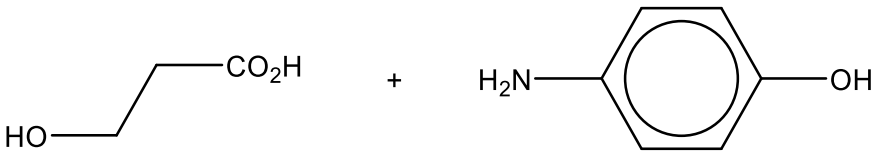
B



C

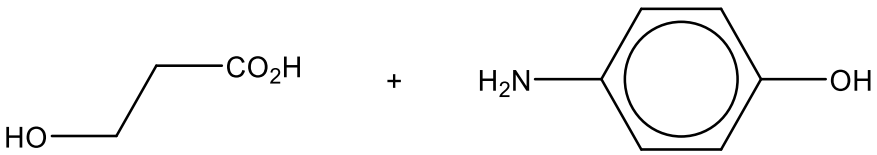


D



Answer: **A**

Compound Z has an amide which will undergo hydrolysis when heated with NaOH(aq) to form a carboxylic acid and an amine as shown below.



The carboxylic acid and phenol will then undergo acid-base reaction with NaOH(aq) to form the sodium salt.

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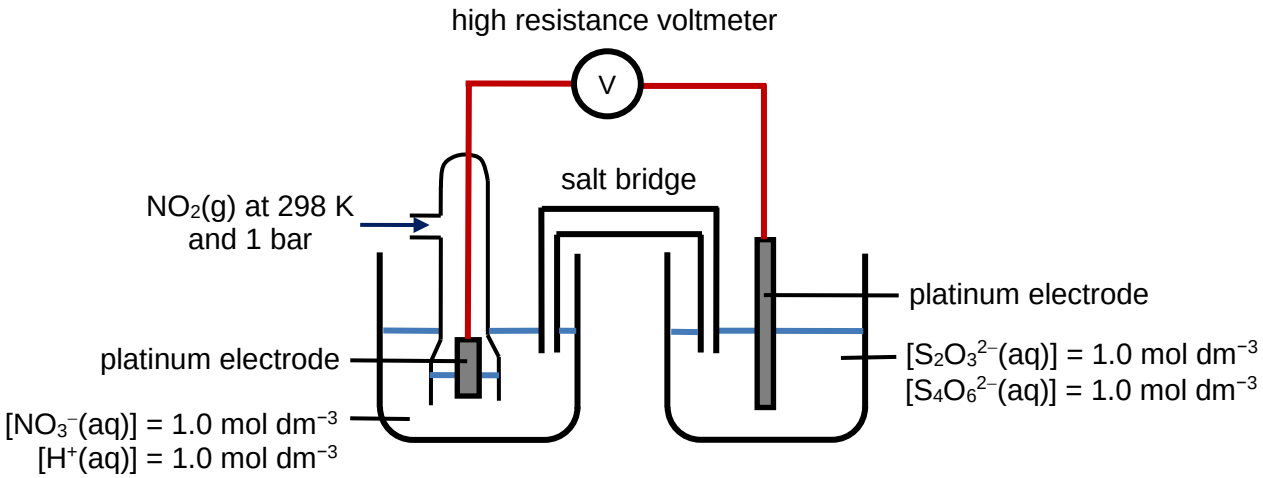
28 *Use of the Data Booklet is relevant to this question.*

The diagram shows apparatus that can be used to measure the standard electrode potential between the NO_3^-/NO_2 half-cell and the $S_4O_6^{2-}/S_2O_3^{2-}$ half-cell.



Which statement is correct?

A The cell potential is 0.90 V.

B Adding sodium hydroxide to the NO_3^-/NO_2 half-cell would increase the cell potential.

C Adding iodine crystals to the $S_4O_6^{2-}/S_2O_3^{2-}$ half-cell would decrease the cell potential.

D The direction of electron flow will reverse when the NO_3^-/NO_2 half-cell is replaced with a Cl_2/Cl^- half-cell.

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Answer: **C**

$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$ $E^\ominus = +0.81$ V
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$ $E^\ominus = +0.09$ V
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$ $E^\ominus = +1.36$ V

A Incorrect.
NO_3^-/NO_2 half-cell = favours reduction (cathode)
$S_4O_6^{2-}/S_2O_3^{2-}$ half-cell = favours oxidation (anode)
$E^\ominus_{cell} = +0.81 - (+0.09) = +0.72$V

B Incorrect.
NaOH reacts with H^+ ions so position of the equilibrium, $NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$, shifts to the left. Hence, $E_{cathode}$ becomes less positive and cell potential will become less positive (decreases).

C Correct.
I_2 reacts with $S_2O_3^{2-}$ so position of the equilibrium, $S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$, shifts to the right,.
Hence E_{anode} becomes more positive and cell potential will become less positive (decreases).

D Incorrect.
Since $E^\ominus(Cl_2/Cl^-) = +1.36$ V, $E^\ominus$ is more positive than $E^\ominus(S_4O_6^{2-}/S_2O_3^{2-})$, reduction will take place in the Cl_2/Cl^- half-cell and hence, there is no change to direction of electron flow.

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

Gold medals awarded in the Olympic Games have a silver core and a pure gold coating of mass 6.0 g. The core of the medal was immersed in a solution of 0.10 mol dm^{-3} gold(III) chloride for 1.5 hours.

What is the current used to achieve an electroplated coating weighing 6.0 g?

A 0.2 A

B 0.5 A

C 1.6 A

D 5.4 A

Answer: C

$Au^{3+} + 3e^- \rightarrow Au$
Amount of Au coated = 6.0 ÷ 197.0 = = 0.030457 mol
Amount of electrons transferrted = 0.030457 × 3 = 0.09137056 mol
$Q = I \times t = n \times F$ so I = (0.09137056 × 96500) ÷ (1.5 × 60 × 60) = 1.6 A

30 When copper(II) nitrate is dissolved in water, it gives a blue solution.
When the blue solution is treated with an excess of aqueous ammonia it turns dark blue.
When the blue solution is treated with an excess of concentrated hydrochloric acid it turns yellow.

What are the formulae of the copper species in the dark blue and yellow solutions?

	dark blue	yellow
A	$[Cu(NH_3)_6]^{2+}$	$[CuCl_6]^{2-}$
B	$[Cu(NH_3)_4(H_2O)_2]^{2+}$	$[CuCl_4]^{2-}$
C	$[Cu(NH_3)_4(H_2O)_2]^{2+}$	$[CuCl_6]^{2-}$
D	$[Cu(NH_3)_6]^{2+}$	$[CuCl_4]^{2-}$

Answer: B

The blue solution is due to $[Cu(H_2O)_6]^{2+}$.
When excess dilute $NH_3(aq)$ is added, ligand exchange reaction occurs whereby four H_2O molecules are replaced by four ammonia molecules.

$$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 4H_2O(l)$$

When excess concentrated hydrochloric acid is added, ligand exchange reaction occurs whereby the six H_2O molecules are replaced by four chloride ions to form a green solution.

$$[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(conc.) \rightleftharpoons [CuCl_4]^{2-}(aq) + 6H_2O(l)$$

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ANSWER KEY

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

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