ST ANDREW'S JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATIONS

HIGHER 2

CANDIDATE NAME	
CLASS	**2 2 S**

CHEMISTRY **9729/01**

Paper 1 Multiple Choice **15 September 2023**

Additional Materials: Multiple Choice Answer Sheet **1 hour**

Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your name and class on the Answer Sheet in the spaces provided.

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.

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 **XX** printed pages (including this cover page) and **1** blank page.

1 The relative atomic mass of boron, which consists of the isotopes $^{10}_{5}B$ and $^{11}_{5}B$ is 10.8.

What is the percentage of $^{11}_{5}B$ atoms in the isotopic mixture?

A 0.2 % **B** 0.8% **C** 20 % **D** 80 %

Ans: D

Let x be the relative abundance of $^{11}_{5}B$

$11x + 10(1-x) = 10.8$

$X = 0.8$

Hence % abundance = 0.8 x 100 = 80%

2 A mixture of sodium iodide, $^{23}Na^{127}I$, and sodium bromide, $^{23}Na^{79}Br$, were vapourised and the ions passed through an electric field.

Which statements about the results are correct?

1 There would be 4 angles of deflections observed.

2 The particle with the largest angle of deflection will be detected at the negative plate.

3 The positive plate will detect more particle types than the negative plate.

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

Ans: B

When the mixture is vapourised, there are only 3 different particle types, Na^+, I^- and Br^-.

Hence, only 3 angle of deflections will be obtained. Statement 1 is wrong.

The (charge/mass) of the 3 particles are $Na^+ = 0.0435$, $I^- = 0.00787$ and $Br^- = 0.0127$.

Therefore, Na^+ will give the largest angle of deflection, which will be detected at the negative place. Hence statement 2 is correct.

Since there are 2 anions and 1 cation, the positive plate will detect one more particle type as compared to the positive place. Statement 3 is correct.

3 Which of the following statements about ice and its structure is correct?

A The bond angle around O in ice is 109.5°.

B Ice is more dense than water.

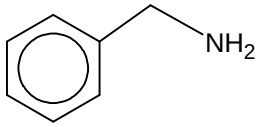
C 2 electrons on O in ice are involved in hydrogen bonding.

D Hydrogen bonds formed in ice are as strong as the O-H covalent bonds.

Ans: A

Ice has an open structure where each O is covalently bonded to 2 H atoms and the 2 lone pairs (4 electrons) each form a hydrogen bond with 2 other neighboring water molecules. (option C is thus incorrect). This leads to O being tetrahedrally bonded to 4 H atoms and thus have a bond angle of 109.5°. (option A is correct). This open structure of ice leads to it being less dense than water (option B is wrong) and thus float on water. Hydrogen bond is an intermolecular force which is weaker than a O-H covalent bond. (option D is wrong)

4 Benzylamine is commonly used in the industrial production of many pharmaceutical products and has the following structure.



Which bond angle is **not** present in benzylamine?

A 105° **B** 107° **C** 109.5° **D** 120°

Ans: A

107° is present about the N as it has 3 bond pairs and 1 lone pair.

109.5° is present on the side chain C as it has 4 bond pairs and 0 lone pair

120° is present as the C on the benzene only has 3 bond pairs and 0 lone pair.

5 In a vessel, 5.0 dm^3 of nitrogen gas at 20 °C and pressure of 200 kPa was compressed by a piston to 2.5 dm^3 and heated to 60 °C.

What is the pressure in the heated vessel?

A 90 kPa **B** 455 kPa **C** 715 kPa **D** 1200 kPa

Ans: B

$P_1V_1 / T_1 = P_2V_2 / T_2$

$(200)(5)/(20+273) = P_2(2.5) / (60+273)$

$P_2 = 454.6 = 455$ kPa (3sf)

6 Magnesium, aluminium, silicon and phosphorus are consecutive elements in Period 3 of the Periodic Table.

Which of the following properties generally decreases from magnesium to phosphorus?

1 Electrical conductivity

2 Ionic radius

3 Melting point of their oxides

4 pH of their chlorides in water

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

Ans: D

Electrical conductivity increases from Mg to Al due to more delocalised electrons in Al in its sea of delocalized electron. Hence incorrect.

The ionic radius of P, being an anion, is larger than the other 3 which are cations. Hence incorrect.

Their structure of their oxides transit from ionic (for Mg) to ionic with covalent character (for Al) to giant covalent (for Si) to simple covalent (for P). Hence their melting point decreases and correct.

The pH of their chlorides starts from around 6 for Mg to 3 for Al to 2 for Si and P. Hence also correct.

7 Which of the following properties of a salt will make it the most soluble in water?

	size of the ions	magnitude of their lattice energy
A	small	small
B	small	large
C	large	small
D	large	large

Ans: A

$\Delta H_{soln} = \sum(\Delta H_{hyd}) - LE$

For a salt to be most soluble, ΔH_{soln} should be a large negative/exothermic value.

Given that both ΔH_{hyd} and LE are negative values, in order for ΔH_{soln} to be a large negative value, the magnitude of ΔH_{hyd} should be large while the magnitude of LE should be small.

$\Delta H_{hyd} \propto$ charge density $= \frac{\text{charge}}{\text{radius}}$

Hence, for magnitude of ΔH_{hyd} to be large, the size of the ions should be small.

Note for review: the interplay between L.E. and hydration energy can be quite tricky – e.g. solubility trend of group 2 sulfates down grp.

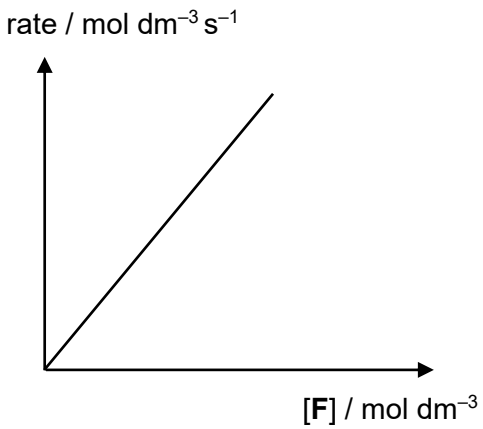
8 A reaction involving 3 species, **F**, **G** and **H** have the following rate equation.

rate = k[**G**][**H**]^2

Which of the following graphs will be obtained?

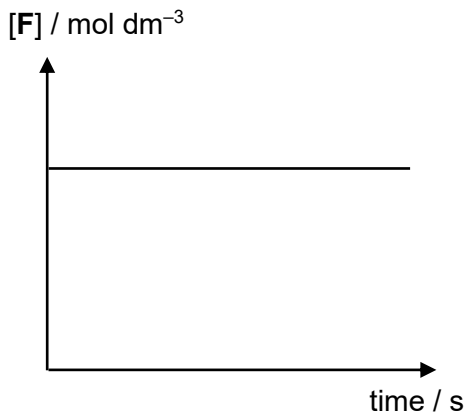
A

When [**G**] and [**H**] are kept constant,



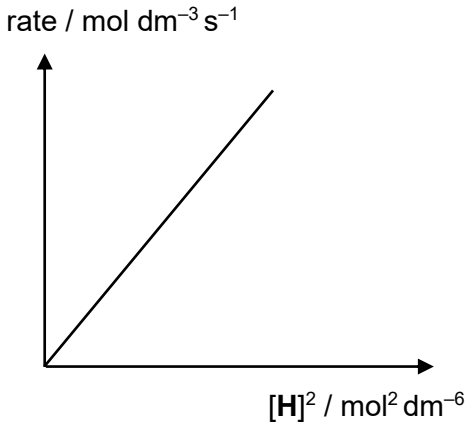
B

When [**G**] and [**H**] are kept constant,



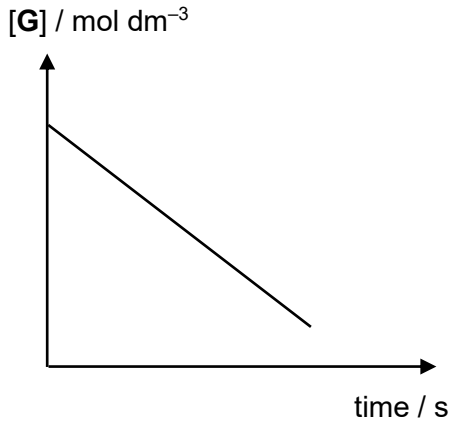
C

When [**F**] and [**G**] are kept constant,



D

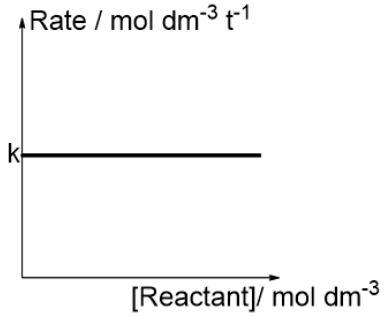
When [**F**] and [**H**] are kept constant,



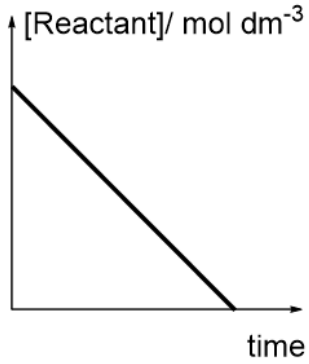
Ans: C

The order of reaction w.r.t [F] is zero.

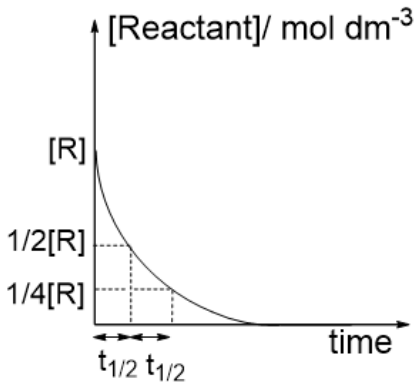
Hence the rate vs conc graph will be



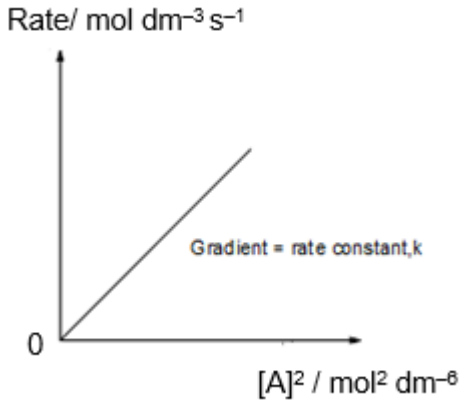
The graph for the [F] vs time graph will be



The order of reaction w.r.t [G] is first order. Hence the [G] vs time will be



The order of reaction w.r.t [H] is second order. Hence the rate vs $[H]^2$ is



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

Hydrogen iodide decomposes according to the equation shown.

$$2HI \rightleftharpoons H_2 + I_2$$

The density of pure hydrogen iodide at 298 K is 2.85 g cm^{-3}.

Which expression gives the concentration of hydrogen gas that are present in 1.00 dm^3 of pure hydrogen iodide at 298 K?

A $K_c\sqrt{\frac{2.85}{127.9}}$ **B** $\frac{2.85}{127.9}\sqrt{K_c}$ **C** $\sqrt{\frac{2850}{127.9}K_c}$ **D** $\frac{2850}{127.9}\sqrt{K_c}$

Ans: D

The $K_c = [H_2][I_2] / [HI]^2$

Therefore,

$[H_2] = \sqrt{(K_c[HI]^2)} = [HI]\sqrt{K_c}$

In 1 dm^3 of pure HI, [HI] = (2.85 x 1000)/M_r of HI = 2850 / 127.9

10 A weak monoacidic base, **J**, has a pK_b value of 3.5.

25.0 cm^3 of 0.08 mol dm^{-3} HC*l* is titrated against 0.10 mol dm^{-3} of **J**.

Which statements about the titration curve obtained are correct?

1 A suitable indicator for this titration is methyl orange.

2 The pH at maximum buffer capacity is 3.5.

3 The region of rapid pH change occurs at 20 cm^3.

4 The volume at maximum buffer capacity is 10 cm^3.

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

Ans: A

This is a weak base-strong acid titration. Hence the salt is acidic. pH at equivalence point will be lower than 7. A suitable indicator is therefore one that has the working range below 7 and methyl orange has working range below 7. Statement 1 is correct.

After the equivalence point, it is a basic buffer. Hence at MBC, pOH = pKb =3.5
Therefore pH = 14 – pKb = 14 - 3.5 = 10.5. Statement 2 is wrong.

Since both acid and base react in a 1:1 ratio,
(25)(0.08) = (V)(0.1)
V = 20 => the equivalence volume (vertical portion of the titration curve) occurs at 20 cm^3. Statement 3 is correct.

A buffer is formed only after equivalence. Hence the maximum buffer capacity (MBC) will occur at 2 time the equivalence volume i.e. 40cm^3. Statement 4 is wrong

11 The K_{sp} of $Mg(OH)_2$ is 1.5×10^{-11} mol^3 dm^{-9} and the K_b of aqueous $CH_3CH_2NH_2$ is 5.6×10^{-4} mol dm^{-3}.

What is the solubility of $Mg(OH)_2$ in 1.0 mol dm^{-3} aqueous $CH_3CH_2NH_2$?

A 1.64×10^{-4} mol dm^{-3} **B** 2.68×10^{-8} mol dm^{-3}

C 4.78×10^{-9} mol dm^{-3} **D** 6.34×10^{-10} mol dm^{-3}

Ans: B

$[OH^-] = \sqrt{5.6 \times 10^{-4}} = 0.023664$ mol dm^{-3}

$[Mg^{2+}] = \frac{1.5 \times 10^{-11}}{0.23664^2} = 2.68 \times 10^{-8}$

12 AgC*l* and AgBr are both partially soluble solids.

$$AgX\ (s) \rightleftharpoons Ag^+\ (aq) + X^-\ (aq), \text{ where X is C}l \text{ or Br} \text{ ------- equation 1}$$

When aqueous NH_3 is added to separate solutions of each silver halide, only AgC*l* dissolves but not AgBr.

Which of the following statements that explains this observation is **correct**?

A The K_{sp} value of AgC*l* is larger than that of AgBr.

B The ionic product for AgC*l* decreases but not the ionic product of AgBr.

C The addition of NH_3 resulted in the formation of the $Ag(NH_3)_2^+$ complex for only AgC*l*.

D The concentration of $Ag^+(aq)$ decreases causing the position of equilibrium of equation 1 to shift to the left.

Ans: A

Since the K_{sp} of AgC*l* is larger than AgBr, the IP of AgC*l* will drop below its K_{sp} causing it to dissolve. For AgBr, the IP will drop but it is still higher than its K_{sp} value and hence it does not dissolve. Option A is correct.

[Ag+] decreases as the complex is formed. This will cause the ionic product (IP) for both AgC*l* and AgBr to decrease. Option B is incorrect.

This also results in the POE of equation 1 to shift to the right for both solutions. Option D is incorrect.

When dilute $NH_3(aq)$ is added to solutions containing the silver halides, the NH_3 will react with the $Ag^+(aq)$ in both solutions to form the $Ag(NH_3)_2^+$ complex. Option C is incorrect.

13 Which of the following statements explains the increase in reducing power of Group 2 element down the group?

A The increase in the nuclear charge down the group.

B The increase in the number of electron shells down the group.

C The melting point of Group 2 metals decreases down the group.

D The electronegativity of Group 2 metals decreases down the group.

Ans: B

The main reason for the increase in reducing power of Group 2 elements down the group is due to the electron shells increasing, resulting in less attraction between the valence electrons and the nucleus, causing them to be more easily lost down the group.

It has nothing to do with melting point or electronegativity. The stability of the cation compared to the metal just explains why Group 2 elements are reducing agent but does not explain the increasing trend.

14 A student added 2 cm^3 of aqueous potassium iodide, KI, into a test tube, followed by bromine, Br_2, dissolved in an organic solvent of density 1.59 g cm^{-3}. He then mixed the solution thoroughly before allowing it to settle.

Which of the following will be observed?

	Observation of the organic solvent	Final colour of the lower layer in the test tube
A	orange-red to purple	colourless
B	orange-red to purple	purple
C	remained orange-red	colourless
D	remained orange-red	orange-red

Ans: B

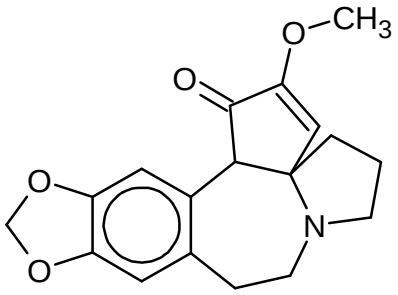
This is a displacement reaction. Since bromine is more reactive than iodine, displacement will take place according to this equation

$$Br_2 + 2I^- \longrightarrow I_2 + 2Br^-$$

Since the iodine is more soluble in the organic solvent, it will turn the organic solvent from the original orange-red to purple.

Since the organic solvent is denser than water (density 1 g cm^{-3}), it will be the lower layer in the test-tube.

15 Cephalotaxine is an alkaloid which has anti-leukemic activity.

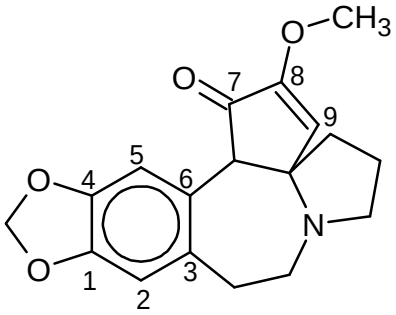


Cephalotaxine

How many carbon atoms are sp^2 hybridised?

A 7 **B** 8 **C** 9 **D** 10

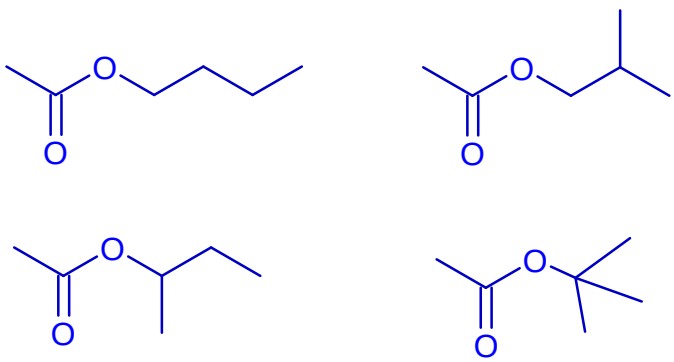
Ans: C



16 How many constitutional isomers with molecular formula $C_6H_{12}O_2$ are esters that form ethanoic acid upon hydrolysis?

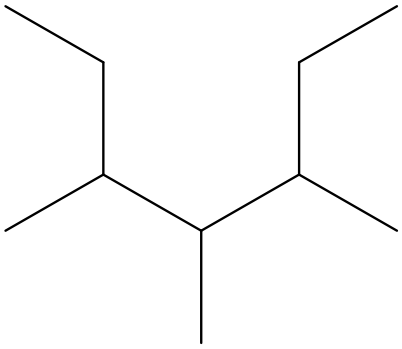
A 2 **B** 3 **C** 4 **D** 5

Ans: C

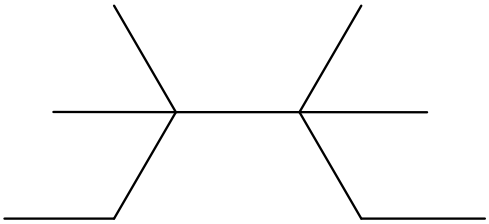


17 Which could be the possible product from the termination step in the chain reaction when 2-methylbutane reacts with Br_2, in the presence of UV light?

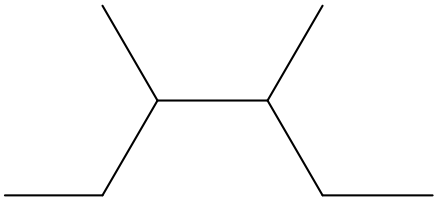
A



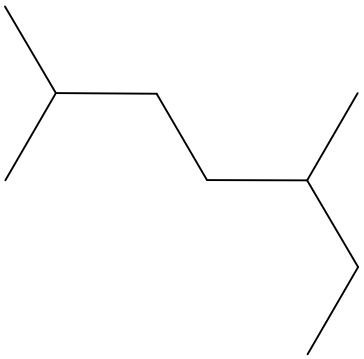
B



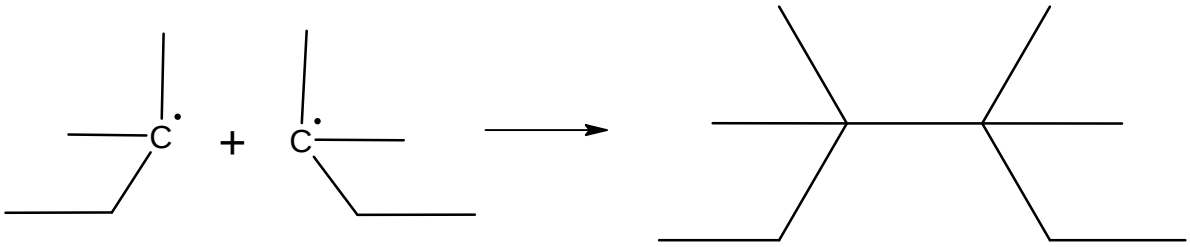
C



D



Ans: B



18 When trichlorofluoromethane, CCl_3F, is released into the atmosphere, it accumulates in the upper part of the atmosphere when it reacts to form free radicals due to the action of the ultraviolet light.

One of the chain reactions which can occur is shown where, Y● represents the halogen radical.

$$Y\bullet + O_3 \longrightarrow YO\bullet + O_2$$

$$2YO\bullet + O_2 \longrightarrow 2Y\bullet + 2O_2$$

1 Both Cl● and F● are the free radicals that cause the breakdown of ozone.

2 The halogen radical acts as a catalyst in the breakdown of the ozone.

3 YOY is one possible product formed in the termination step.

Which statements are correct?

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

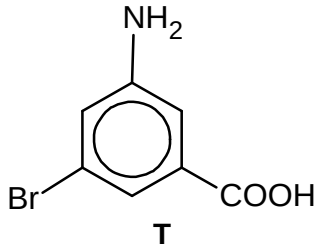
Ans: C

1 False. The C-Cl bond breaks more easily than C-F bond. Hence the major radicals are and $\bullet CCl_2F$ and $\bullet Cl$.

2 True. It is used up in the 1st step (in the eqns shown) and regenerated in the second step.

3 True. Termination step involves radicals combining to form molecules. YO● and Y● to form YOY.

19 The following molecule, **T**, can be synthesised from benzene via several steps.



T

Which of the following synthesis routes would give the highest yield for **T**?

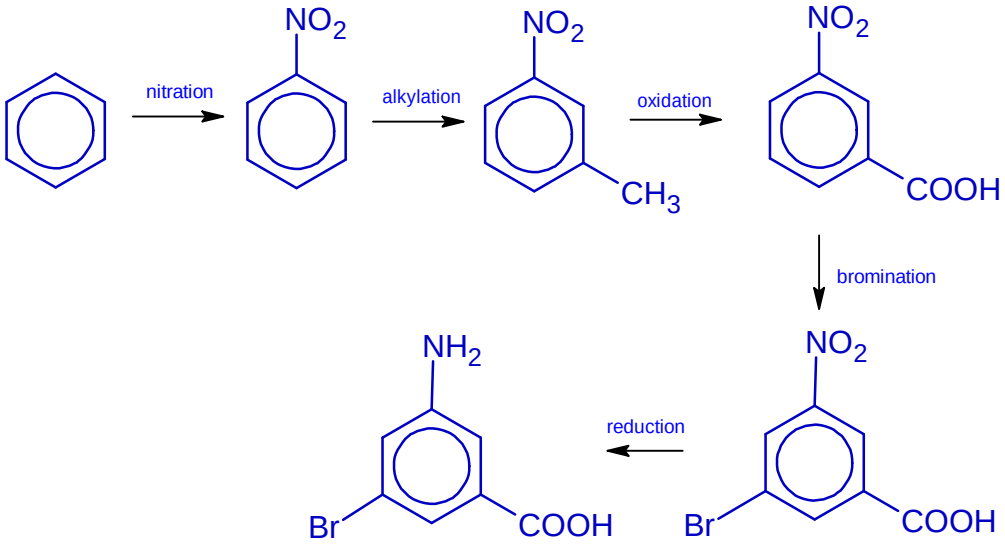
A alkylation → oxidation → nitration → reduction → bromination

B nitration → alkylation → oxidation → reduction → bromination

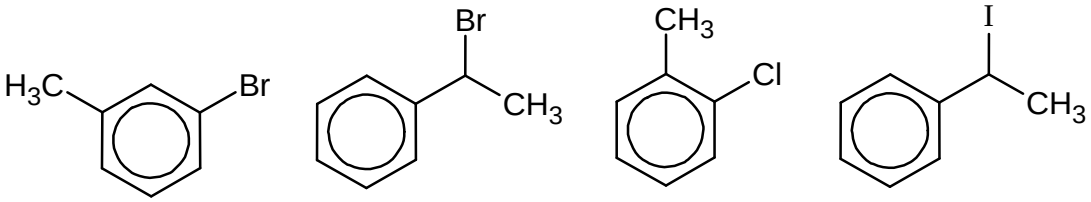
C alkylation → nitration → oxidation → bromination → reduction

D nitration → alkylation → oxidation → bromination → reduction

Ans: D



20 Equal amounts of compounds **W**, **X**, **Y** and **Z** are added separately to four test-tubes containing equal concentrations of ethanolic silver nitrate solution in a heated water bath. No precipitate forms in two of the tubes. In the two other tubes, precipitates form at different rates.



W **X** **Y** **Z**

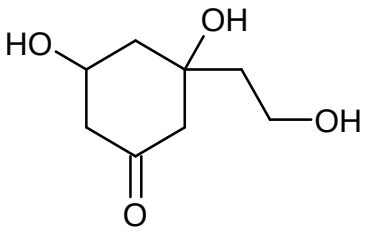
Which row is correct?

	compounds which do not form a precipitate	colour of the precipitate which forms the slowest
A	**W** and **X**	Cream
B	**W** and **X**	White
C	**W** and **Y**	Cream
D	**W** and **Y**	Yellow

Ans: C

Chlorobenzene (Y) and bromobenzene (W) are resistant to nucleophilic substitution. C-Br bond is stronger than C-I bond, hence the precipitate of AgBr (cream) is formed the slowest.

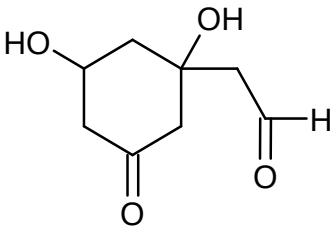
21 Compound **Q** is heated under reflux with an excess of acidified potassium dichromate (VI).



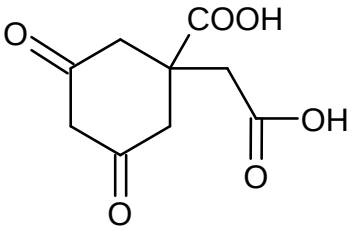
Q

What could be the structure of the main organic product?

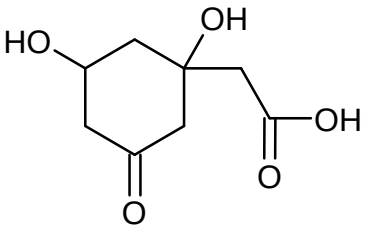
A



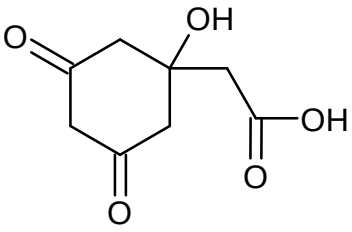
B



C



D



Ans: D

The primary -OH is oxidised to –COOH and the secondary –OH is oxidised to become ketone while the tertiary –OH remains unchanged. As heat conditions is applied, primary –OH will oxidise –CHO formed further to become –COOH.

22 Compound **S** has the molecular formula $C_xH_yO_z$. It is tested with various reagents and gives the following results.

- When **S** is treated with a reducing agent $NaBH_4$, it forms a product with the molecular formula $C_xH_{y+2}O_z$.
- **S** can form a compound with molecular formula $C_xH_yO_{z+1}$ in a single reaction.
- **S** gives a silver mirror with ammoniacal solution of silver nitrate.
- **S** does not react with Na metal.

What conclusion can be drawn from these results?

A **S** has a ketone functional group.

B **S** has an aldehyde functional group.

C **S** has a primary alcohol functional group.

D **S** has both an aldehyde functional group and a ketone functional group.

Ans: B

No reaction with Na shows no ROH, phenol or RCOOH is present in **S**.

When $R_2C=O$ is reduced, it forms a secondary alcohol, $R_2CH(OH)$, so two H is added.

If RCHO is present, it forms a primary alcohol, which will be $RCH_2(OH)$, two H is added.

Hence, both aldehyde and ketone could be present.

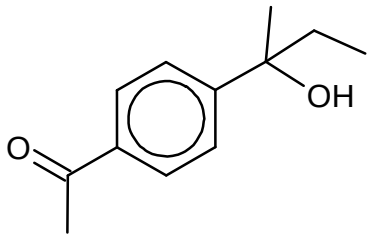
However, only RCHO can be transformed to RCOOH (additional of one O) with an oxidising agent such as hot acidified $KMnO_4(aq)$.

Reaction with Tollens' reaction (ammoniacal solution of silver nitrate) proves that **S** contains an aldehyde.

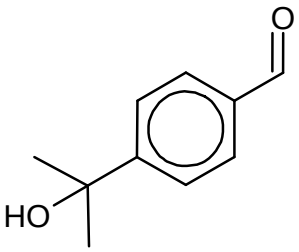
23 Compound **J** reacts with alkaline aqueous iodine to form a yellow precipitate.

Which is **not** a possible structure of Compound **J**?

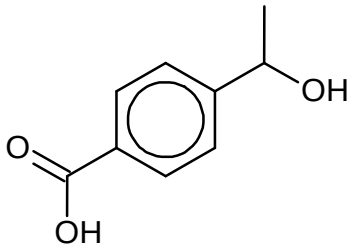
A



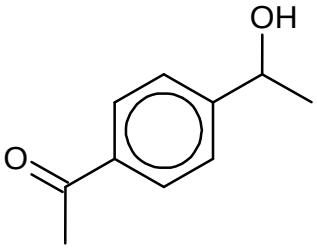
B



C



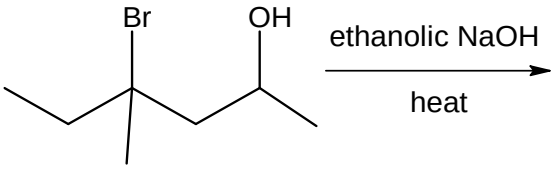
D

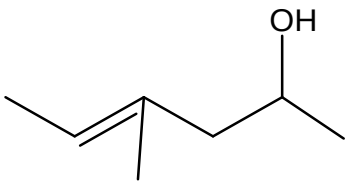


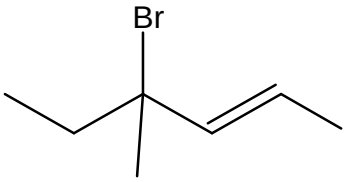
Ans: B

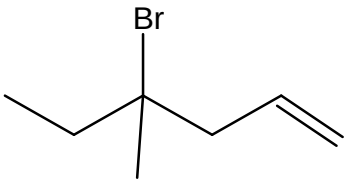
To have yellow ppt with alkaline aqueous iodine, there should be secondary $CH_3(OH)C$- or methyl ketone. Option B does not have either of them.

24 What are the possible products that could be formed in the following reaction?



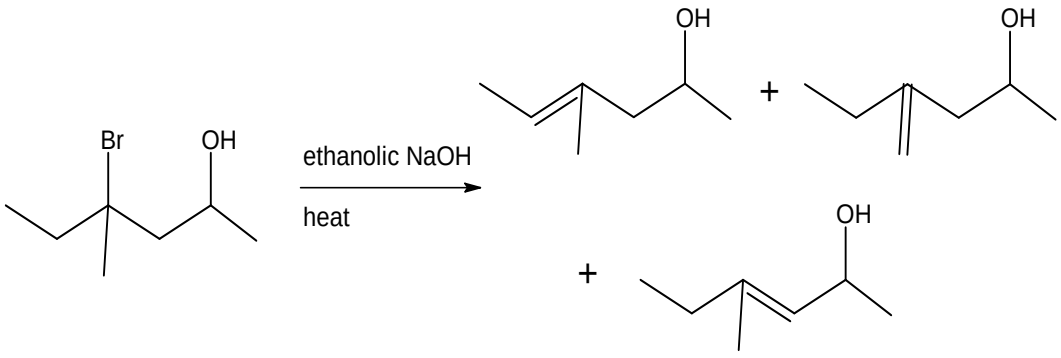
1 

2 

3 

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

Ans: C



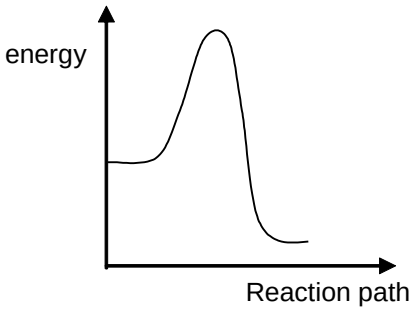
This is an elimination of HBr and not H_2O. The reagents and conditions of elimination H_2O is excess concentrated sulfuric acid, heat.

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

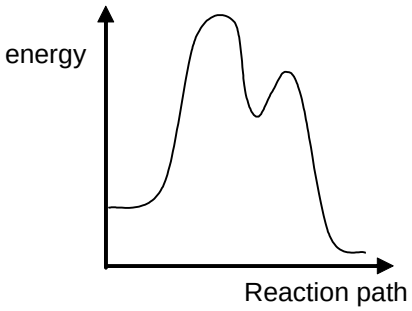
When an optically active sample of 2-chlorobutane is heated with aqueous KOH, the product, 2-butanol, is formed with an inversion of the chiral centre.

Which diagram represents the reaction profile for this mechanism?

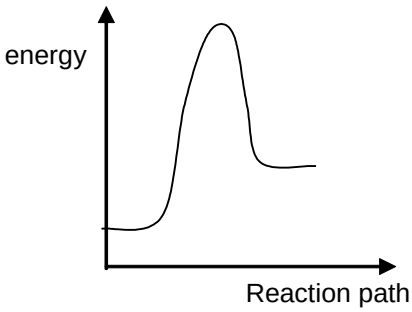
A



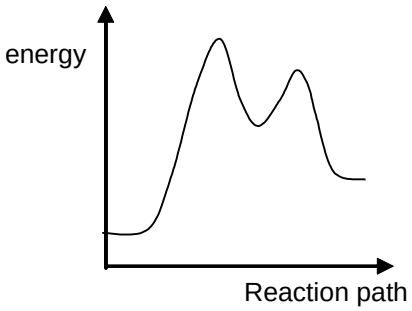
B



C



D

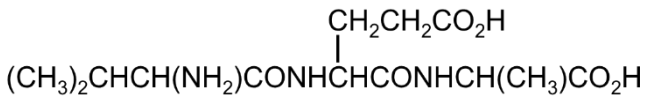


Ans: A

Inverted compound means S_N2 mechanism, so one-step meachanism.

C-Cl bond is weaker than C-O bond hence the net enthalpy change of reaction is exothermic.

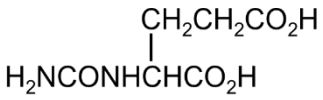
26 Partial hydrolysis of insulin, the hormone essential for carbohydrate metabolism, gives the following tripeptide.



Which compound could be obtained by further hydrolysis of this tripeptide?

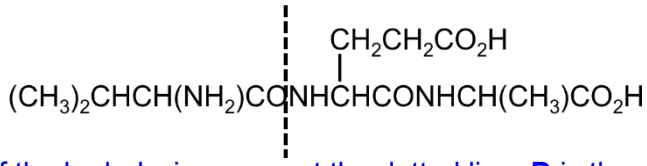
A $CH_3CH(CO_2H)_2$

B $(CH_3)_2CHCH(NH_2)CONH_2$

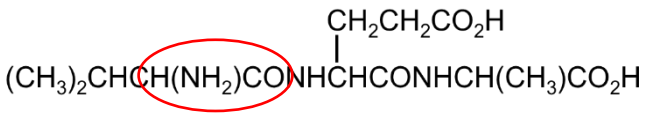
C 

D $CH_2(CO_2H)CH_2CH(NH_2)CONHCH(CH_3)CO_2H$

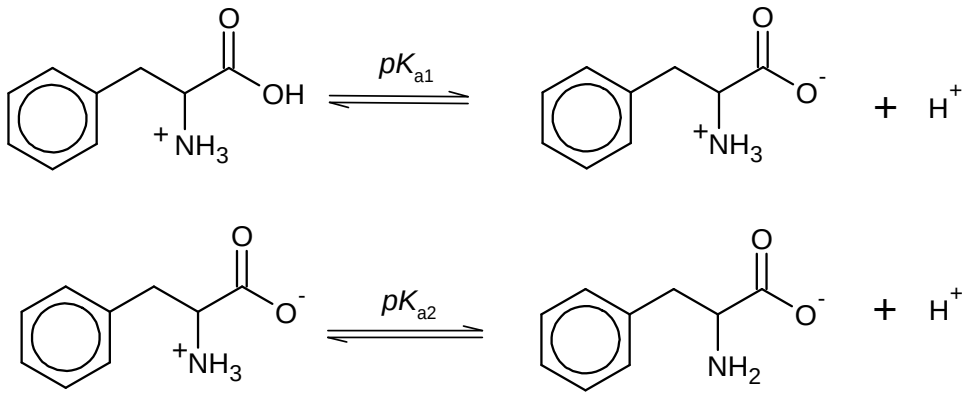
Ans: D



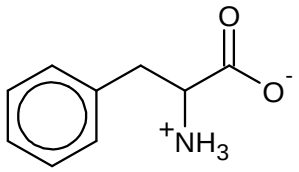
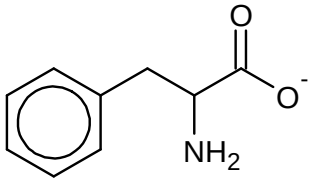
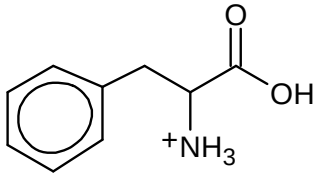
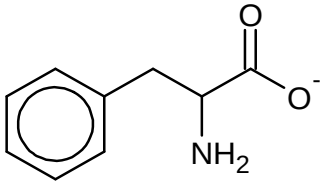
If the hydrolysis occurs at the dotted line, **D** is the compound that will be produced. The rest of the options has compounds that do not coincide with the structure of the compounds produced when hydrolysis takes place at other amide bonds.

Option C is wrong as  does not have the N directly bonded to the carboxyl carbon!

27 The amino acid phenylalanine exists as different ionic species depending on pH.



Which row could be correct?

	pK_{a1}	pK_{a2}	Formula of phenylalanine ion at pH 7
A	2.2	9.3	
B	2.2	9.3	
C	9.3	2.2	
D	9.3	2.2	

Ans: A

When pH>pKa (7>2.3), the -COOH dissociates $-COO^-$.

When pH<pKa (7<9.3), the $-NH_2$ protonates to become NH_3^+.

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

Which of the following are chemically stable when left to stand in the atmosphere?

1 Bromine

2 A solution of tin(II) chloride, $SnCl_2$

3 A solution of vanadyl sulfate pentahydrate, $VOSO_4.5H_2O$

4 Zn metal

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

Ans: C

When something is left to stand in atmosphere, it must not be oxidized by oxygen in air in order to be chemically stable.

Therefore, oxygen will undergo reduction according to this half equation.

$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$ $E^\ominus = +0.40$ ($E^\ominus$(cathode))

A reaction will take place, $E^\ominus$ (cell) has to be positive and $E^\ominus$(anode) is less than or equal to + 0.40V.

Option 1 will not take place as bromine can only be reduced (found on the left side of the arrow). Hence it will be stable when left to stand in atmosphere.

Option 2 the relevant half equations are

$Sn^{4+} + 2e \rightleftharpoons Sn^{2+}$ $E^\ominus = +0.15$

$Cl_2 + 2e \rightleftharpoons 2\,Cl^-$ $E^\ominus = +1.36$

The $E^\ominus$ for Sn^{4+}/Sn^{2+} is less than +0.40V and hence there will be reaction between air and Sn^{2+} and it won't be stable when left to stand in atmosphere.

Option 3 the relevant half equations are

$VO_3^- + 4H^+ + e \rightleftharpoons VO^{2+} + 2H_2O$. $E^\ominus = +1.00$

$VO_2^+ + 2H^+ + e \rightleftharpoons VO^{2+} + H_2O$. $E^\ominus = +1.00$

$S_2O_8^{2-} + e \rightleftharpoons 2SO_4^{2-}$ $E^\ominus = +2.01$

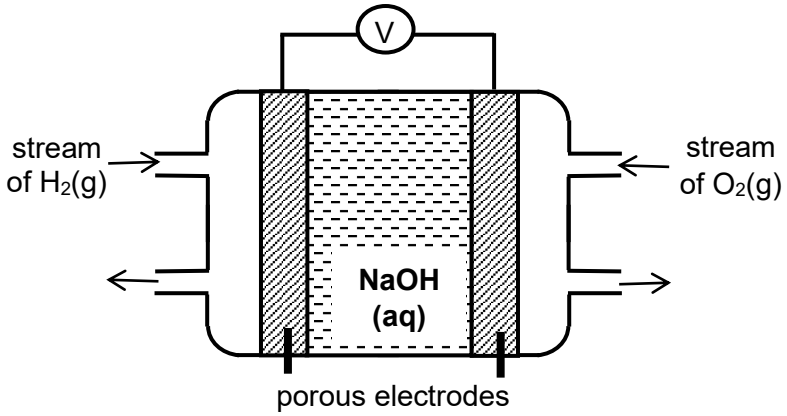
All $E^\ominus$ are greater than +0.40V resulting in a negative E(cell). Hence it will be stable when left to stand in atmosphere.

Option 4 the relevant half equations are

$Zn^{2+} + 2e \rightleftharpoons Zn$ $E^\ominus = -0.76V$

The $E^\ominus$ for Zn^{2+}/Zn is less than +0.40V and hence there will be reaction between air and Zn and it won't be stable when left to stand in atmosphere.

29 A hydrogen-oxygen fuel cell is constructed using 1.00 mol dm^{-3} sodium hydroxide as the electrolyte. What is the change in pH of the solution around each electrode when the current is flowing?



	Cathode	Anode
A	Increase	increase
B	Increase	decrease
C	Decrease	increase
D	Decrease	decrease

Ans: B

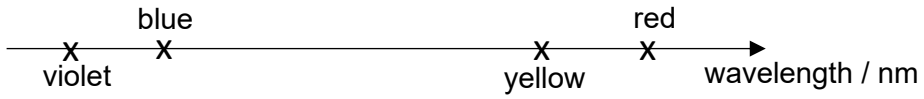
$O_2 + 2H_2O + 4e \rightleftharpoons 4OH^-$ + 0.40 V

$2H_2O + 2e \rightleftharpoons H_2 + 2OH^-$ −0.83

At cathode, OH^- is produced and hence pH should increase.

At anode, OH^- is used and hence pH should decrease.

30 The following shows the relative wavelengths of some colours in the visible light spectrum.



When acidified hydrogen peroxide is added to a solution of $[Fe(CN)_6^{4-}]$, the colour of the solution changed from yellow to Prussian blue.

Given that wavelength and energy are inversely proportional, which of the following best accounts for what took place?

	Number of d-electrons in Fe	Energy gap between the d-orbitals in Fe
A	change	decrease
B	change	increase
C	remain the same	decrease
D	remain the same	increase

Ans: A

The reaction between H_2O_2 and $[Fe(CN)_6^{4-}]$ is a redox reaction. This means Fe in the complex will change its oxidation state, leading to a change in the number of d-electrons in Fe.

Species	Colour reflected	Colour absorbed	Wavelength	Energy
$[Fe(CN)_6]^{4-}$	Yellow	Violet / blue	Shorter	Higher
$[Fe(CN)_6]^{3-}$	Blue	Yellow / red	Longer	Lower

From the information given, when colour change from yellow to blue, wavelength of visible light absorbed changes (change from violet light absorbed to red light absorbed) which means energy gap will decrease since they are inversely proportional.

END OF PAPER