Catholic Junior College
JC 2 Preliminary Examinations
Higher 2

CANDIDATE NAME	
CLASS	**2T**

CHEMISTRY 9729/01

Paper 1 Multiple Choice **15 September 2023**

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, class and NRIC/FIN number 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.

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.

WORKED SOLUTIONS

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

1 What volume of air is required for the complete combustion of 1.0 dm^3 of octane vapour, C_8H_{18} (g), in a car engine? (Air contains 20% oxygen by volume.)

A 2.5 dm^3 **B** 12.5 dm^3 **C** 62.5 dm^3 **D** 125.0 dm^3

Topic: Mole Concept

Combustion of octane: $C_8H_{18} + \frac{25}{2} O_2 \rightarrow 8CO_2 + 9H_2O$

Volume of O_2 needed = 1 x $\frac{25}{2}$ = 12.5 dm^3

Volume of air needed = $\frac{100}{20} \times 12.5$ = 62.5 dm^3

Answer: C

2 The ionisation energies, in kJ mol^{-1}, of three elements are given in the table.

	1st ionisation energy	2nd ionisation energy	3rd ionisation energy
Ne	2080	3950	6150
Na	494	4560	6940
Mg	736	1450	7740

Which statement(s) about these ionisation energies is/are correct?

1 Ne has the greatest 1st ionisation energy of the three elements because its electrons experience the most interelectronic repulsion.

2 Mg has the lowest 2nd ionisation energy of the three elements because the electron being removed experiences the greatest shielding effect.

3 There is a large increase from the 2nd to 3rd ionisation energy of Na because the electron is being removed from the next inner subshell.

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

Topic: Atomic Structure

Electronic configuration of Ne: $1s^22s^22p^6$; Na: $1s^22s^22p^62s^1$; Mg: $1s^22s^22p^62s^2$

Statement 1 – Wrong. Ionization energy (IE) depends on nuclear charge, distance of electron from nucleus, and shielding effect. Out of the three elements, Ne has the smallest nuclear charge, but the electron being removed is from the 2nd principal quantum shell compared to Na and Mg (3rd principal quantum shell), and experiences less shielding effect, hence greatest attraction from nucleus, and greatest amount of energy required to remove it.

Statement 2 – Correct. Out of the three elements, Mg has the greatest nuclear charge but this is outweighed by greater shielding effect (2 inner shells vs 1 inner shell for Ne^+ and Na^+), hence weakest attraction from nucleus on the valence electron being removed, and lowest 2nd IE.

Statement 3 – Wrong. 2nd and 3rd electron removed are both from the 2p subshell (electrons are removed from 2p before 2s subshell as 2p is higher in energy). 8th electron to be removed

3 Equimolar amounts of the liquids hexane, $CH_3(CH_2)_4CH_3$, and triethylamine, $(CH_3CH_2)_3N$, are mixed together at 20 °C. The original intermolecular forces are disrupted and stronger intermolecular forces between $CH_3(CH_2)_4CH_3$ and $(CH_3CH_2)_3N$ are formed simultaneously.

The boiling point of hexane is 69 °C. The boiling point of triethylamine is 90 °C.

Which row is correct?

	initial temperature of mixture	boiling point of mixture
A	above 20 °C	below 69 °C
B	below 20 °C	below 69 °C
C	below 20 °C	above 90 °C
D	above 20 °C	above 90 °C

Topic: Chemical Bonding (modified from 2020/I/5)

Since the question stem states that stronger intermolecular forces (IMF) are formed after mixing, energy released from forming the new IMF greater than the energy absorbed to break original IMF (exothermic process overall), hence the initial temperature of mixture should rise to above 20 °C, before equilibrating back to room temperature.

Since the resulting IMF are stronger, the energy required to separate the molecules during boiling is also larger than that in pure hexane and triethylamine respectively. Thus, the boiling point of the new mixture is above 90 °C.

Answer: D

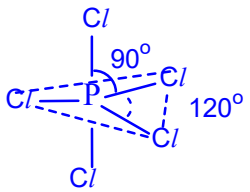
4 In the gaseous state, phosphorus(V) chloride exists as a molecule with the formula PCl_5. However, when it is a solid, it is ionic with the formula $PCl_4^+PCl_6^-$.

Which one of the following statements is correct?

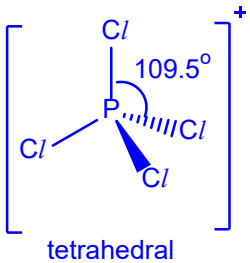
A The bond angle in PCl_4^+ is smaller than that in PCl_6^-.
B There is a dative covalent bond in PCl_6^-.
C The P atom in PCl_4^+ has an expanded octet.
D There is a net dipole moment in PCl_5.

Topic: Chemical Bonding

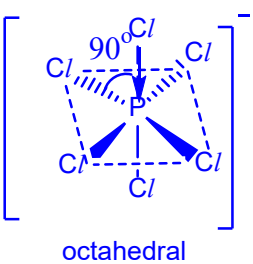
Option A: Wrong. The bond angle in PCl_4^+ is 109.5° while the bond angle in PCl_6^- is 90°.
Option B: Correct. There is a dative bond from Cl^- to P.
Option C: Wrong. There are only 8 electrons surrounding P in PCl_4^+.
Option D: Wrong. The dipole moments cancel out in PCl_5.



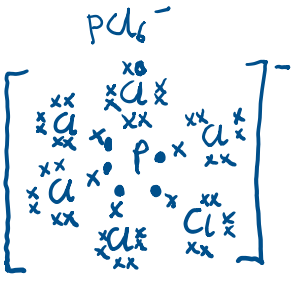
trigonal bipyramidal



tetrahedral



octahedral



Answer: B

5 Which pairs of compounds contain a polar and a non-polar molecule?

1 CO_2, H_2O

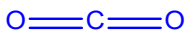
2 SO_2, NO_2

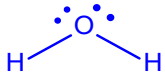
3 CH_2Cl_2 , $SiCl_4$

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

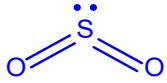
Topic: Chemical Bonding

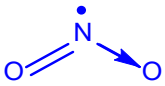
Option 1: Yes, CO_2 is non-polar while H_2O is polar



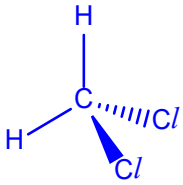


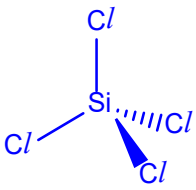
Option 2: No, both SO_2 and NO_2 have bent shapes and are polar.





Option 3: Yes, CH_2Cl_2 is polar while $SiCl_4$ is non-polar





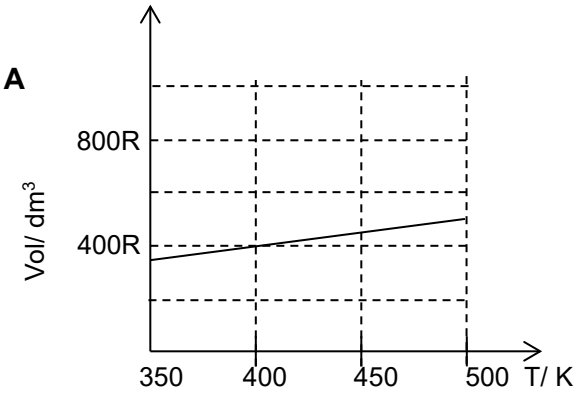
Answer: B (1 and 3 only)

6 A gaseous dimer, $\mathbf{X}_2$, dissociates into its gaseous monomer, **X**, at 400 K and 1 atm pressure. Dissociation is complete at 450 K.

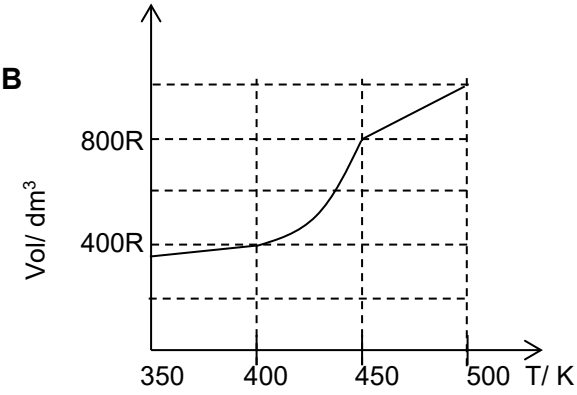
$$\mathbf{X}_2\,(g) \rightarrow 2\mathbf{X}\,(g)$$

Which of the following graphs shows the variation of volume with temperature when one mole of $\mathbf{X}_2$ is heated from 350 K to 500 K at a constant pressure of 1 atm? Assume that the gases behave ideally. ($R = 0.082\ mol^{-1}\ dm^3\ atm\ K^{-1}$)

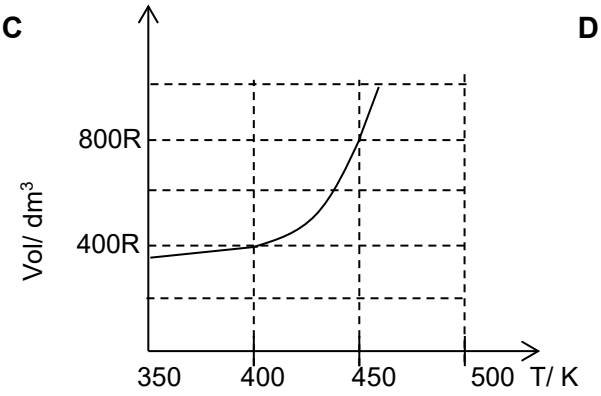
A



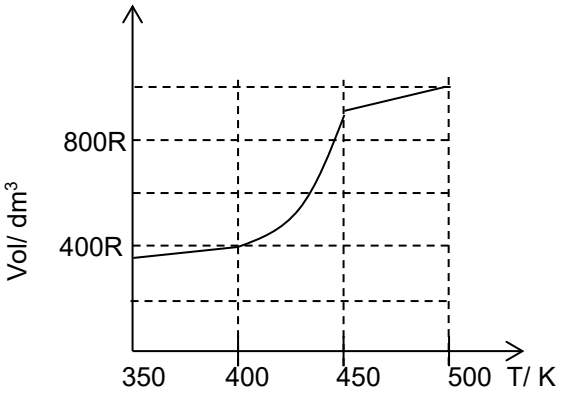
B



C



D



Topic: Gaseous State

Concept: Ideal Gas equation pV = nRT

Answer: D

PV=nRT

V = (nR/P) T

Pressure is kept constant ∴ V initially varies linearly with T with constant gradient (nR/P).

Then at 400 K, dissociation occurs, and n increases as well, hence gradient increases, until 450 K.

The V at 450 K should be 900R, as V=(2R/1)(450)= 900R.

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

At 400 K, the following species behave as ideal gases: H_2, CH_4, NO_2, Ar. 5.00 g of each of these gases is put separately into a gas syringe kept at 400 K.
The volume of each gas is adjusted to be the same, and pressure is measured.

Which gas will have the lowest pressure?

A H_2
B CH_4
C NO_2
D Ar

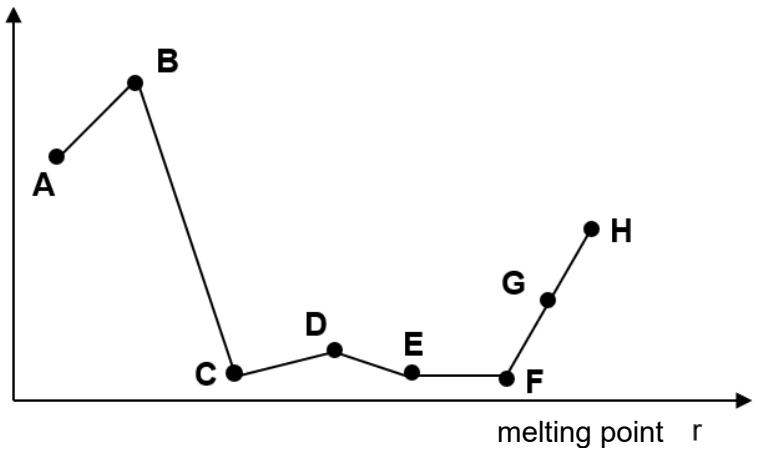
Topic: Gaseous State

Answer: C

pV = nRT where V, R and T are the same for all four gases. So **p ∝ n.**
(shortcut to the last column and the answer is to consider the **greatest M_r** will give **smallest number of moles** for the **same mass,** and hence **lowest pressure**)

Gas	M_r *or* A_r	n= 5.00/M_r
H_2	2.0	2.50
CH_4	16.0	0.313
NO_2	46.0	0.108
Ar	39.9	0.125

8 The graph below shows the variation in the melting point for 8 consecutive elements in the Periodic Table, all with atomic number ≤ 20.



What can be deduced from the graph?

A The ions of **A** and **E** are isoelectronic.
B The chlorides become less acidic from **A** to **C**.
C When the oxide of **C** is added to water, the resulting solution has a pH greater than 7.
D The oxide of **A** reacts with excess aqueous sodium hydroxide to form a soluble complex.

Topic: The Periodic Table

Answer : D

Drastic drop in boiling point from **B** to **C** => change in structure from giant covalent to simple covalent. Si has the highest melting point across period 3. **B** is Silicon, **C** is Phosphorus.

Option A is wrong. **A** is Aluminium (Group 13). Ions of **A** (Al^{3+}) and **E**(Cl^-) are not isoelectronic (Cl^- has 8 more electrons than Al^{3+})

Option B is wrong. Chloride of **A** ($AlCl_3$) is acidic (pH = 3) due to significant hydrolysis of water to give H_3O^+ ions, chlorides of **B** ($SiCl_4$) and **C** (PCl_5) are more acidic as they produce strong acid HCl in water.

$$AlCl_3(s) + 6H_2O(l) \rightarrow [Al(H_2O)_6]^{3+}(aq) + 3Cl^-(aq)$$
$$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H_3O^+$$
$$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$$
$$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$$

Option C is wrong. Oxide of **D** is P_4O_{10}. $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ which is acidic (pH < 7).

Option D is correct. Oxide of **A** (Al_2O_3) is amphoteric and can react with both acids & bases. It reacts with excess aq NaOH to form soluble complex $Na[Al(OH)_4]$.

9 Which of the following processes are endothermic?

1 $N_2(g) + O_2(g) \rightarrow 2NO(g)$
2 $O^-(g) + e^- \rightarrow O^{2-}(g)$
3 $C(s) + O_2(g) \rightarrow CO_2(g)$

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

Topic: Energetics (endothermic reactions)

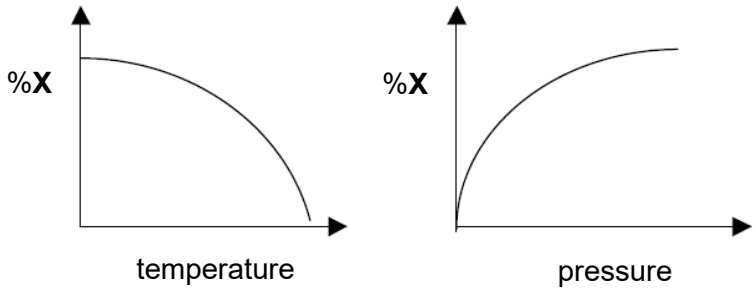
1 $N_2(g) + O_2(g) \rightarrow 2NO(g)$
To break the N≡N triple bond requires a high amount of energy (very endothermic). The product formed, NO, is also unstable as it is a radical. Hence the reactants are considered very stable molecules, and the product is relatively unstable. The reaction will be endothermic.

2 $O^-(g) + e^- \rightarrow O^{2-}(g)$

This equation is the second electron affinity (EA) of oxygen. For second EA, energy is absorbed (endothermic) because the incoming second electron must overcome the repulsion from the (negatively charged) anion.

3 $C(s) + O_2(g) \rightarrow CO_2(g)$
Enthalpy change of combustion of carbon is exothermic. Carbon is completely burnt in oxygen to form a stable product.

10 The graphs below show how the percentage of reactant **X**(g) in an equilibrium varies with changes in temperature and pressure.



Which of the following conclusions about the above equilibrium can be drawn from this information?

A The forward reaction is exothermic.
B Addition of a catalyst will have a greater effect on the rate of reverse reaction than the rate of forward reaction.
C The equation for the reaction could be in the form of W(g) + **X**(g) ⇌ 2 Y(g) + Z(g).
D The value of K_c decreases as pressure increases.

Concept: Chemical Equilibria

The first graph shows less **X**(g) being formed as temperature increases, so forward reaction is endothermic. (Option A is incorrect.)
Addition of a catalyst reduces the activation energy of the forward and reverse reactions by the same amount, so option B is wrong.
The second graph shows more **X**(g) being formed as pressure increases. The total number of gaseous reactants must be fewer than the gaseous products. (Option C agrees with this).
Value of K_c only changes with temperature changes, hence option D is wrong.

Answer: C

11 The rate of removal of a new drug from the body is a first-order reaction. 75 % of the initial drug present in a patient is removed over 5.4 h.

How much time will it take to remove 90% of this drug from the body?

A 6.75 h **B** 8.10 h **C** 8.97 h **D** 10.8 h

Concept: Reaction Kinetics

Half-lives	0	$t_{1/2}$	2 x $t_{1/2}$
Amt. of drug remaining	1	½	¼
Amt. of drug removed	0	(1-½) = 1/2	(1-1/4) = ¾ = 0.75

2 x $t_{1/2}$ =5.4 h
$t_{1/2}$ = 2.7 h.

$C_t/C_o = (1/2)^n$
$10/100 = (1/2)^n$
n = 3.32

3.32 x $t_{1/2}$ = 8.97 h

Answer: C

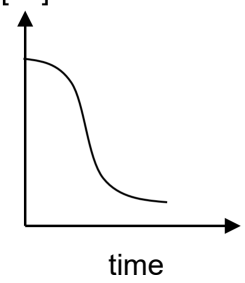
12 The chlorite-tetrathionate reaction, in which the chlorite ion is one of the reactants, has been studied. One of the products, $H^+(aq)$, catalyses the reaction.

$$2S_4O_6^{2-} + 7ClO_2^- + 6H_2O \rightarrow 8SO_4^{2-} + 7Cl^- + 12H^+$$

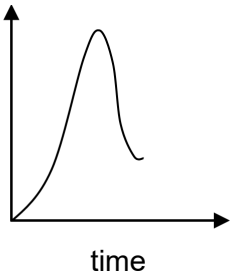
tetrathionate chlorite

Which graph best describes the above reaction?

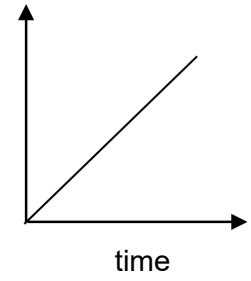
A



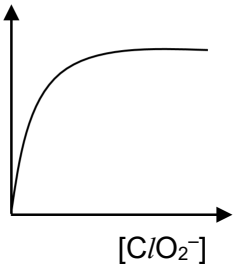
B



C



D



Concept: Reaction Kinetics

The reaction is an autocatalysis. At the start, rate is slow, but it increases as more and more of the autocatalyst (H^+) is produced. Eventually, as concentration of reactants decrease, the value of rate starts to decrease.

Answer: B

13 Metal sulfides are generally insoluble. K_{sp} values for copper sulfide and zinc sulfide at 298 K are listed in the table below.

metal sulfide	colour	K_{sp} / mol^2dm^{-6}
CuS	black	6.3×10^{-36}
ZnS	white	1.6×10^{-24}

When aqueous copper sulfate is added to white solid of ZnS, black precipitate of CuS is observed according to the following reaction.

$$ZnS(s) + Cu^{2+}(aq) \rightleftharpoons CuS(s) + Zn^{2+}(aq)$$

What is the equilibrium constant, K_c, for the reaction above?

A 1.0×10^{-59} **B** 3.9×10^{-12}

C 5.0×10^{5} **D** 2.5×10^{11}

Concept: Manipulation of K_{sp}, K_c expressions

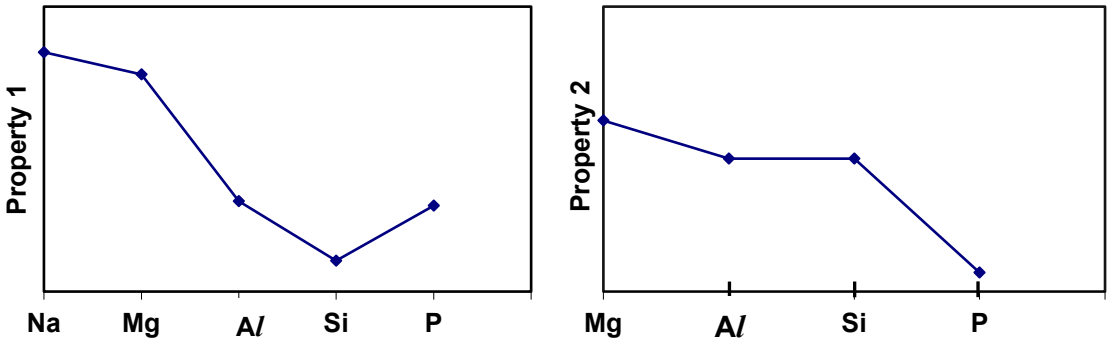
K_{sp} CuS = $[Cu^{2+}][S^{2-}]$ K_{sp} ZnS = $[Zn^{2+}][S^{2-}]$

$K_c = \frac{[Zn^{2+}]}{[Cu^{2+}]} = \frac{Ksp\ ZnS}{Ksp\ CuS}$

$= \frac{(1.6 \times 10^{-24})}{(6.3 \times 10^{-36})} = 2.5 \times 10^{11}$

Answer: D

14 The graphs below show the variation of two properties of some period 3 elements and/or their compounds.



Which of the following correctly describes properties 1 and 2?

	property 1	property 2
A	atomic radius of the elements	electrical conductivity of the elements
B	melting point of the chlorides	pH of oxides when added to water
C	melting point of the elements	first ionisation energies of the elements
D	electrical conductivity of elements	pH of chlorides when added to water

Topic: Periodic Table

Property 1: melting point of chlorides

Chlorides of Mg form giant ionic lattice structures, have much higher melting point than simple molecular chlorides of Al, Si and P

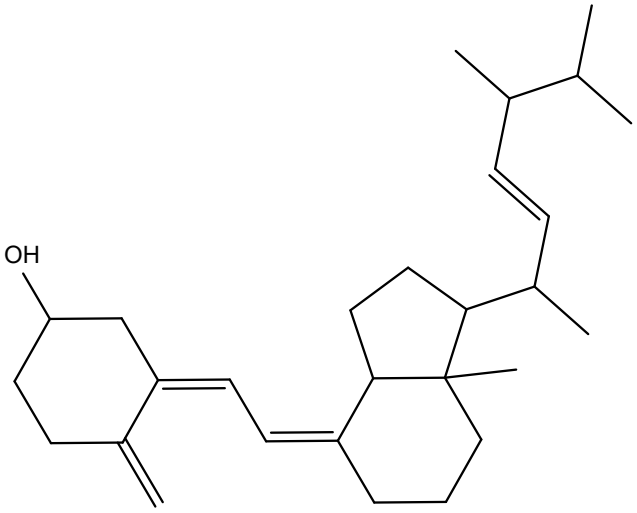
Property 2: pH of oxides

oxides	MgO	Al_2O_3	SiO_2	P_4O_{10}
Structure	giant ionic lattice		giant molecular	simple molecular
Reaction with water	weakly alkaline solution (pH ≈ 9)	insoluble (pH = 7)		acidic solution (pH = 1)

The most obvious clue to identifying the property would be the plateau from Al to Si, which is due to the insoluble oxides of the two elements.

Answer: B

15 The structure of vitamin D2 is shown below.



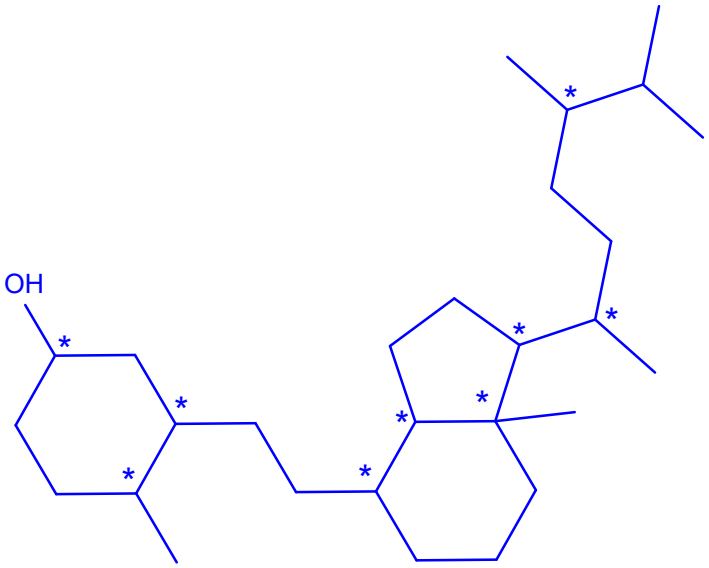
vitamin D2

When it is completely reacted with hydrogen in the presence of a palladium catalyst at room temperature, how many chiral centres does the product molecule possess?

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

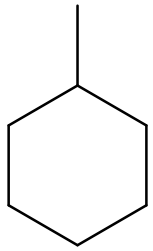
Concept: Introduction to Organic Chemistry, Alkenes

The product formed is:



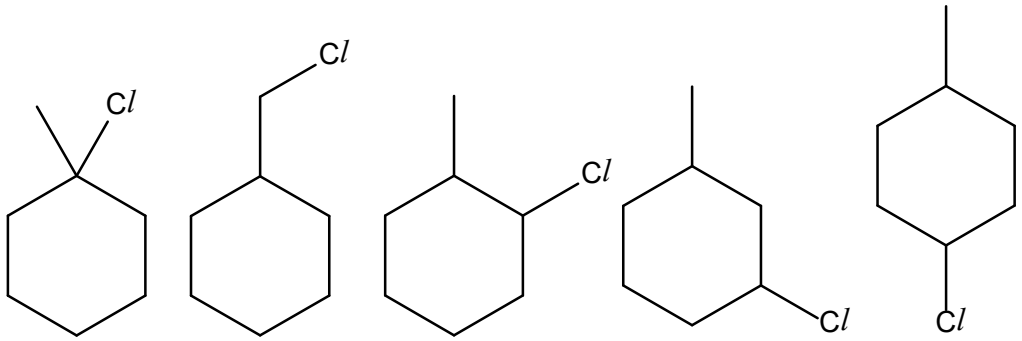
Answer: C

16 Methylcyclohexane was reacted with limited chlorine in the presence of *uv* light.



methylcyclohexane

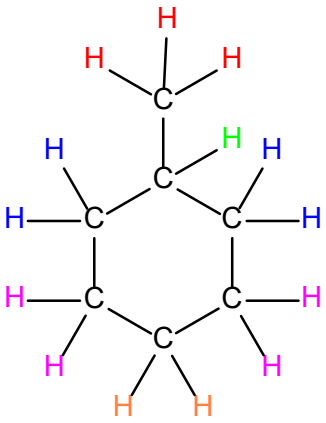
Assuming that only mono-chlorination takes place, and the reaction occurs at the same rate at all carbon atoms, what is the ratio of the products obtained below?



A	1	:	3	:	4	:	4	: 2
B	1	:	3	:	2	:	2	: 2
C	1	:	1	:	4	:	4	: 2
D	1	:	3	:	4	:	2	: 1

Concept: Alkanes

Structure of methylcyclohexane is as follows:



Answer: A

17 Compound **S** upon reaction with hot acidified potassium manganate(VII) yields CH_3COCH_3, $CH_3COCH_2CH_2CO_2H$ and $CH_3CH_2CO_2H$.

Which compound could be **S**?

A $CH_3CH=C(CH_3)CH_2CH_2C(CH_3)=CHCH_2CH_3$

B $(CH_3)_2C=CHCH_2CH_2C(CH_3)=CHCH_2CH_3$

C $(CH_3)_2C=CHCH_2CH_2C(CH_2OH)=CHCH_3$

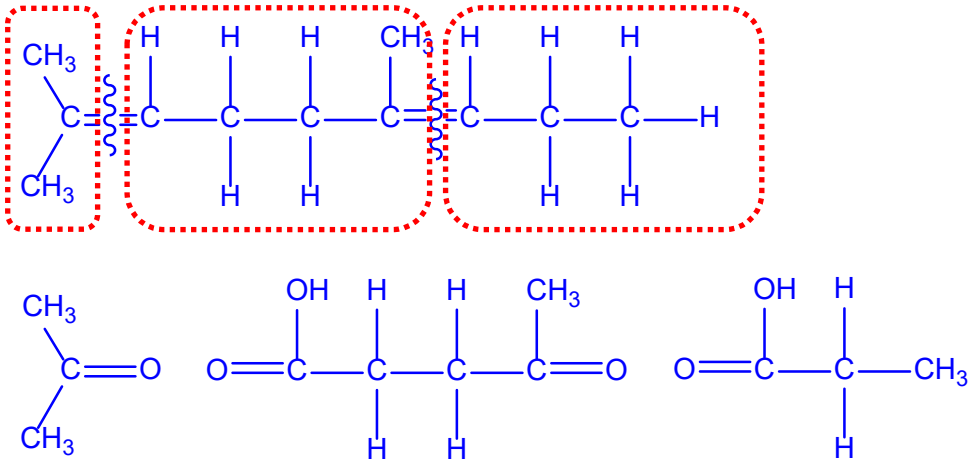
D $(CH_3)_2C=C(CH_3)CH_2C(CH_3)=CHCH_2CH_3$

Concept: Alkenes

Products formed from oxidation of alkene

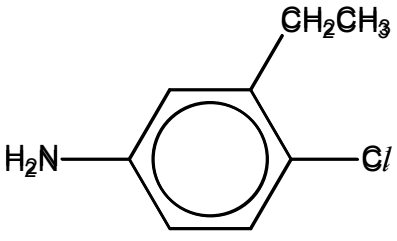
The fastest way is to identify the correct functional groups (ketone, carboxylic acid), then number of carbons, then look at the specific structure.

Or combine the products of the oxidation and then check against the options given.



Answer: B

18 Which synthetic route is most likely to lead to the most successful synthesis of the following product from benzene?



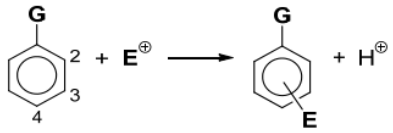
A nitration, chlorination, alkylation, reduction

B nitration, alkylation, reduction, chlorination

C nitration, reduction, alkylation, chlorination

D alkylation, nitration, chlorination, reduction

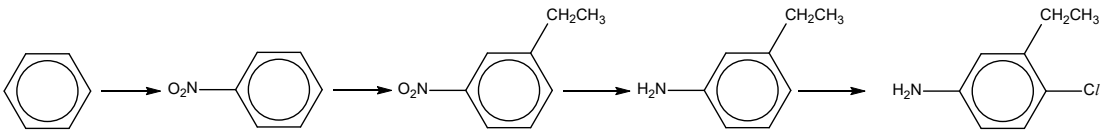
Topic: Arenes
Concept: Orientating effect of groups in aromatic substitution reactions



G	–alkyl –OH or –OR –NH_2, –NHR or –NR_2 –NHCOR	–Cl, –Br, –I	–CHO, –COR –CO_2H, –CO_2R –NH_3^+ –NO_2, –CN
Reactivity of ring (compared to benzene)	Activated	Deactivated	Deactivated
Position of E (relative to position of G)	2- and/or 4-	2- and/or 4-	3-

Option A which starts with nitration will not result in chlorine at position 4 as nitro group is position 3 directing.

Option B will result in the best yield because the nitro group is position 3 directing which results in ethyl group at position 3 and after reduction of nitro group both amine and ethyl group and 2,4 directing and will direct chloro group to the correct position as shown in the product.



Option C results in the alkyl group at position 2 or 4 after the formation of amine.

Option D results in the nitro group at position 2 or 4 after alkylation.

Answer: B

19 The following two reactions occur under identical conditions and proceed via the same mechanism. It was found that reaction 1 occurs faster than reaction 2.

reaction 1: $CH_3CHBrCH_3 + NaCN \rightarrow CH_3CH(CN)CH_3 + NaBr$
reaction 2: $CH_3CHBrCH_3 + NaI \rightarrow CH_3CHICH_3 + NaBr$

What could be the most likely explanation?

A The C–I bond is a stronger bond than the C–Br bond.
B The C–N bond is a stronger bond than the C–I bond.
C The CN^- ion is a stronger nucleophile than the I^- ion.
D The Br^- ion is a stronger nucleophile than the I^- ion.

Topic: Halogen Derivatives
Concept: Nucleophilic Substitution in RX

Answer: C

Option A : The C–I bond is a weaker bond than the C–Br bond.
Option B : The C–N bond is not broken in the mechanism.
Option C : The CN^- ion is a stronger nucleophile than the I^- ion, hence the substitution proceeds faster.
Option D : The nucleophiles in reaction 1 and 2 are CN^- ion and I^- ion respectively. The bromide ion is not acting as a nucleophile.

20 Which of the following halogenoalkanes will undergo an S_N1 reaction and produce a white precipitate when $AgNO_3(aq)$ is added to it?

A 1-chloroethane
B 1-bromoethane
C 2-chloro-2-methylpropane
D 2-iodo-2-methylpropane

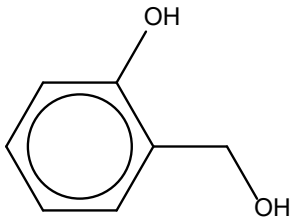
Topic: Halogen derivatives
Concept: S_N1 vs S_N2, Hydrolysis of RX

Tertiary halogenoalkane generally undergoes S_N1 reaction. The white ppt is AgCl, hence the halogenoalkane must be a chloroalkane.

2-chloro-2-methylpropane is a tertiary halogenoalkane. Hence, answer is **C**.

Answer: C

21 Saligenin is a white solid with the following structure.



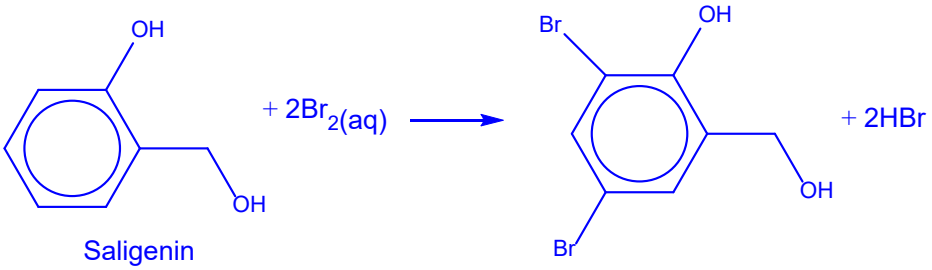
saligenin

Separate samples of one mole of saligenin each are mixed with $Br_2(aq)$ and NaOH(aq) respectively. How many moles of $Br_2(aq)$ and NaOH(aq) will react?

	$Br_2(aq)$	NaOH(aq)
A	0	1
B	1	2
C	2	2
D	2	1

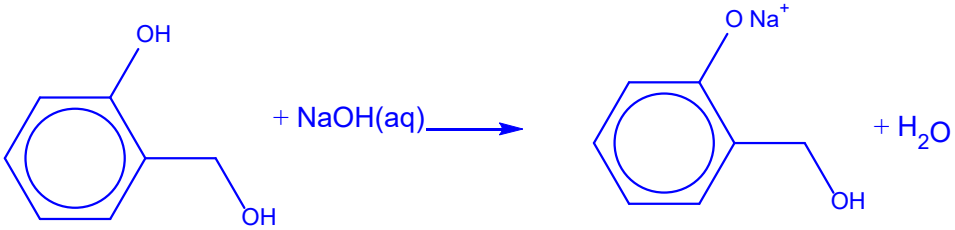
Concept: Hydroxy Compounds

The phenol group will allow for electrophilic substitution of $Br_2(aq)$ at rtp on positions 2, 4 and 6 of the benzene ring. But since position 2 already has a substituent, only positions 4 and 6 will allow for Br^+ electrophile to be substituted.



Saligenin

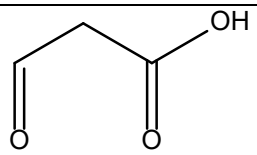
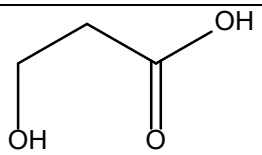
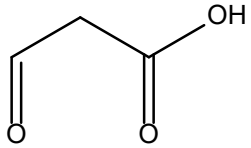
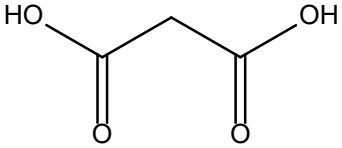
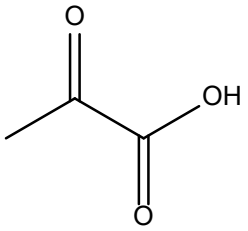
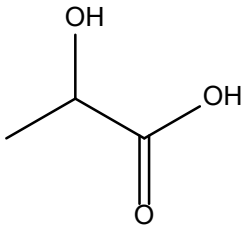
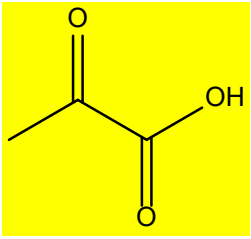
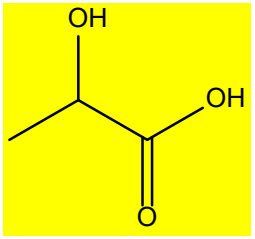
NaOH(aq) only reacts with the phenol group and not the alcohol group.



Saligenin

Answer: D

22 Pyruvic acid, $C_3H_4O_3$, contains a carboxylic acid functional group and another functional group that forms an orange precipitate with 2,4-dinitrophenylhydrazine. Pyruvic acid undergoes reduction to form lactic acid. But during this reduction reaction, the acid functional group does not react. Which one of the following rows gives the correct details of this reaction?

	suggested structure of pyruvic acid	reagents and conditions	suggested structure of lactic acid
A		LiA/H_4 in dry ether	
B		$NaBH_4$ in methanol	
C		LiA/H_4 in dry ether	
D		$NaBH_4$ in methanol	

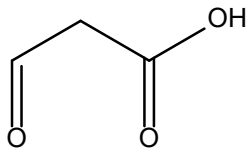
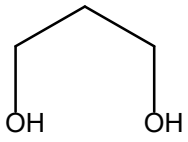
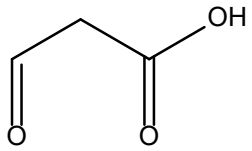
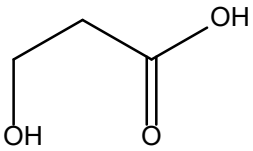
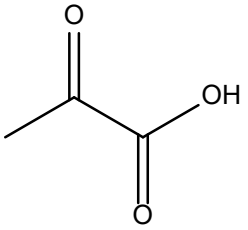
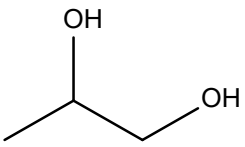
Concept: Carbonyl compounds

The two proposed structures for pyruvic acid fit the description in the question. (Aldehyde or ketone will give orange ppt with 2,4-DNPH.)

But for the carboxylic acid functional group to remain unchanged in pyruvic acid, $LiAlH_4$ in dry ether cannot be used as it will reduce the carboxylic acid to a primary alcohol. (Options **A** and **C** are incorrect.)

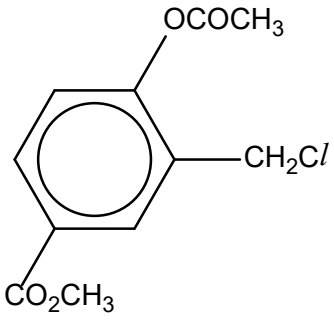
As for Option **B**, the product is incorrect. It shows the oxidized product instead of the reduced product.

The correct products for options **A** to **C** are as follows:

	suggested structure of pyruvic acid	reagents and conditions	suggested structure of lactic acid
A		$LiAlH_4$ in dry ether Both aldehyde and carboxylic acid will be reduced	
B		$NaBH_4$ in methanol Aldehyde only will be reduced, and not oxidised	
C		$LiAlH_4$ in dry ether Both ketone and carboxylic acid will be reduced	

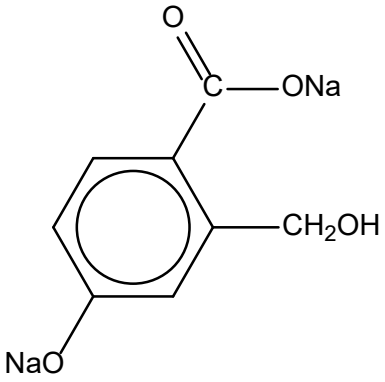
Answer: D

23 Which one of the following represents the organic product when an excess of hot aqueous sodium hydroxide is added to compound **R**?

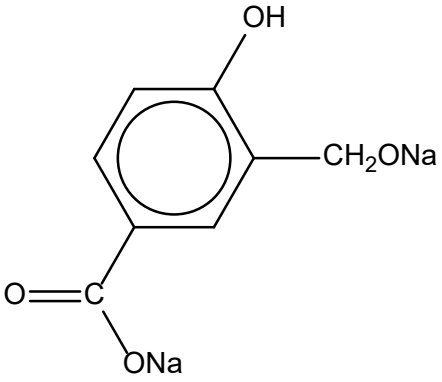


R

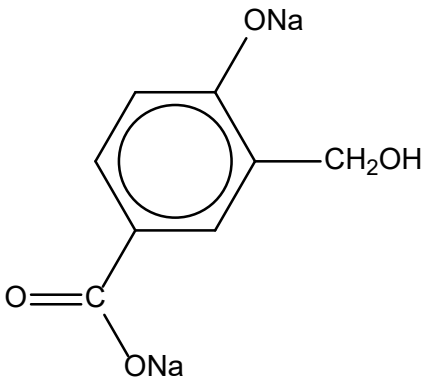
A



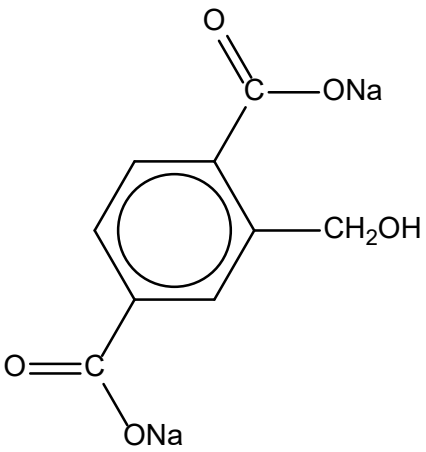
B



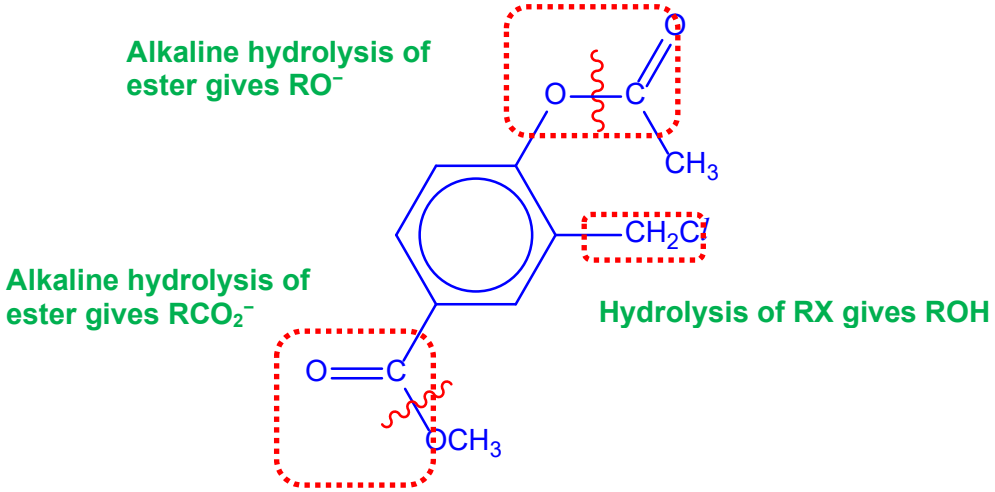
C



D



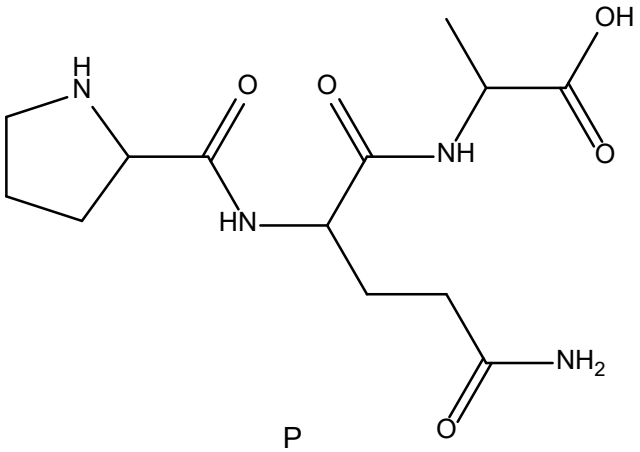
Concept: Carboxylic Acid & Derivatives
Products formed from alkaline hydrolysis of ester



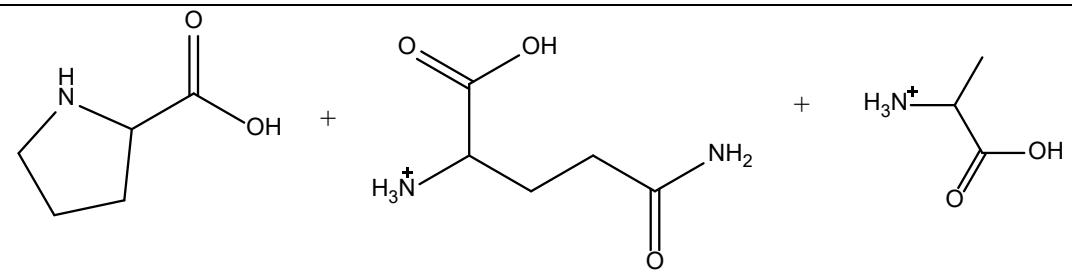
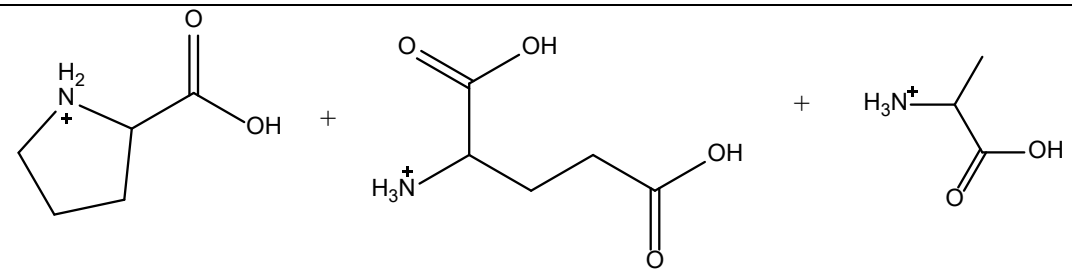
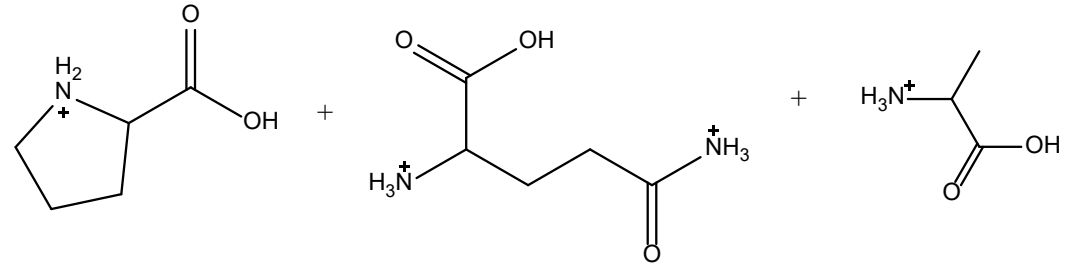
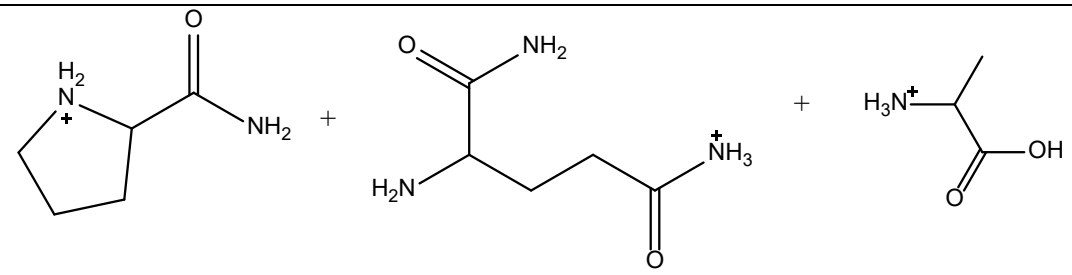
The products formed from the hydrolysis of the ester further react with sodium hydroxide to form salts of phenols and carboxylic acids. Alcohols do not react further with sodium hydroxide.
Answer: C

24 The tripeptide **P** is made by reacting three different amino acids together.

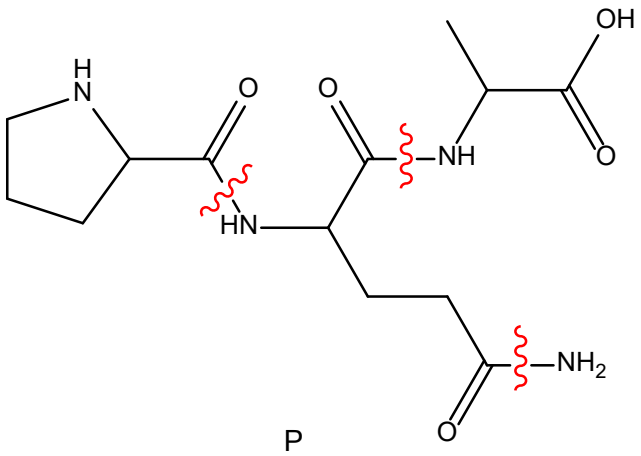
When **P** is reacted with hot HC*l*(aq), what will be the most likely organic product(s) formed?



P

A	
B	
C	
D	

Concept: Nitrogen Compounds (Amines, amides)

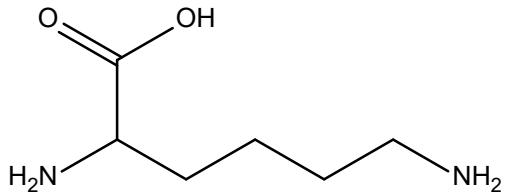


P

The C-N bonds of the peptide (amide) bonds as well as the amide side chain are hydrolysed, and the basic amine groups are protonated in acidic medium.

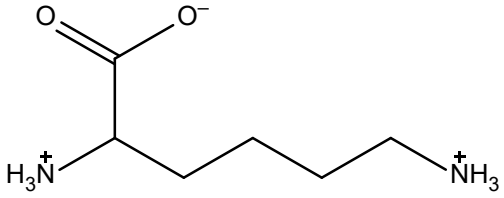
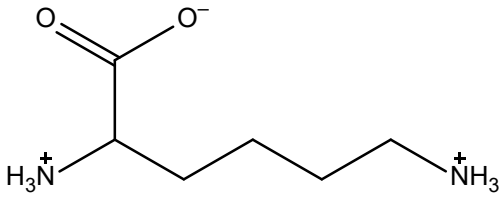
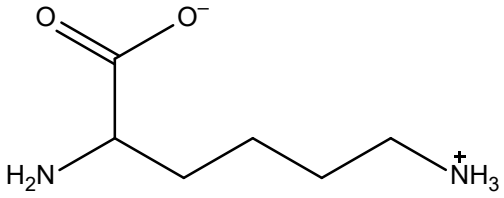
Answer: B

25 Lysine is an amino acid with pK_a values 2.16, 9.06 and 10.54.



lysine

Which of the following show the correct predominant structure when lysine is in an aqueous solution at the respective pH?

	pH	predominant structure
1	3	
2	7	
3	10	

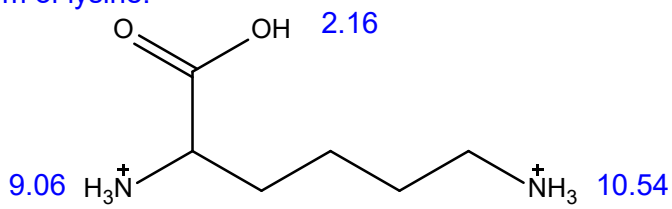
A 1 only **B** 2 only **C** 1 and 3 only **D** 1, 2 and 3

Concept: Nitrogen Compounds – Amino acids

pK_a values can be assigned to the following groups as shown below. The side chain $–NH_2$ is the strongest base (ie. weakest conjugate acid, highest pK_a) as it is further away from the electron-withdrawing $–CO_2H$ group, hence lone pair is most available.

When pH < pK_a, the group is protonated, but when pH > pK_a, the group is deprotonated.

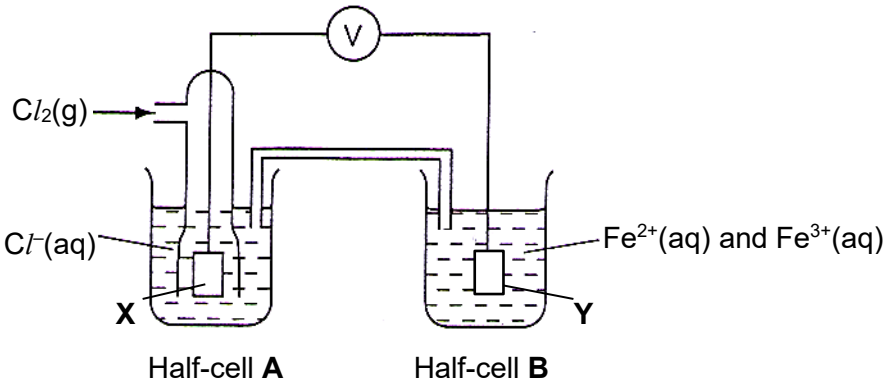
Fully protonated form of lysine:



Answer: D (1, 2 and 3)

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

The cell shown in the diagram is set up under standard conditions where **X** and **Y** are platinum electrodes.



Which of the following statements is correct?

A Changing **Y** to Fe in half-cell **A** will not affect $E^{\ominus}_{cell}$.
B The voltmeter will show a reading of about 2.13 V.
C The electrons will flow from **Y** to **X** through the voltmeter.
D **X** will be the negative electrode.

Topic: Electrochemistry
Concept: Finding value of E_{cell} and movement of charge carriers

Relevant half-equations:

$Fe^{2+} + 2e^- \rightleftharpoons Fe$ $\quad E^{\ominus} = -0.44V$
[O] $Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$ $\quad E^{\ominus} = +0.77V$
[R] $Cl_2 + 2e^- \rightleftharpoons 2Cl^-$ $\quad E^{\ominus} = +1.36V$

A. By changing **Y** to Fe, Fe will undergo oxidation instead of Fe^{2+} as the $E^{\ominus}(Fe^{2+}/Fe)$ is more negative than $E^{\ominus}(Fe^{3+}/Fe^{2+})$.

B. Correct cell emf = 1.36 – 0.77 = 0.59V

C. Half-cell **B** is the anode undergoing oxidation (loss of electrons) since the $E^{\ominus}(Fe^{3+}/Fe^{2+})$ is less positive than $E^{\ominus}(Cl_2/Cl^-)$ and electrons flow from the anode to the cathode.

D. In an electrochemical cell, the electrode will have positive polarity in the half-cell where reduction takes place, Hence, **X** will be the positive electrode.

Answer: C

27 An aqueous solution of copper(II) salt is electrolysed between copper electrodes, using a constant current. What affects the mass of copper deposited on the cathode?

1 the time taken
2 the concentration of solution
3 the size of the electrodes

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

Concept: Faraday's first law

The amount of charge determines the amount of copper produced. Charge is only dependent on current and time.

Answer: D

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

In the electrolysis of molten lead(II) bromide, 2.072 g of lead is liberated when 1940 coulombs of electricity is passed through molten lead(II) bromide. Which value of Avogadro's constant do **these figures** give?

A 6.02×10^{23} **B** 6.06×10^{23} **C** 3.03×10^{23} **D** 1.21×10^{24}

Topic: Electrochemistry

$Pb^{2+} + 2e^- \longrightarrow Pb$
mol of Pb = $\frac{2.072}{207.2} = 0.0100$ mol
mol of electrons = 0.0200 mol

Q = mol of electrons x F (experimental)
1940 = 0.0200 x F
F = 97000 $Cmol^{-1}$

F = Le
97500 = L x (1.6×10^{-19})
L = 6.06×10^{23}

Answer: B

29 When a few drops of $NH_3(aq)$ are added to $Cu(NO_3)_2(aq)$, a pale blue precipitate is formed. This precipitate dissolves when an excess of $NH_3(aq)$ is added, forming a deep blue solution.

Which process does not occur in this sequence of reactions?

A ligand exchange
B acid-base reaction
C precipitation
D redox reaction

Topic: Transition Metals

When a small amount of ammonia is added, a pale blue precipitate of $Cu(OH)_2$ is formed.

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ …(1) Acid-base reaction

(NH_3 is acting as a weak base here)

$Cu^{2+} + 2OH^- \rightleftharpoons Cu(OH)_2$ (s) …(2) precipitation

In excess ammonia,

$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4(H_2O)_2]^{2+}$ (aq) + $4H_2O$ …(3) ligand exchange

- Stronger NH_3 ligands displace H_2O ligands in a ligand exchange reaction to form a deep blue complex $[Cu(NH_3)_4(H_2O)_2]^{2+}$.
- As concentration of $[Cu(H_2O)_6]^{2+}$ is decreased, position of equilibrium (2) shifts left.

➔ Pale–blue precipitate of $Cu(OH)_2$ dissolves.

Cu^2 remained in +2 oxidation state throughout.

Answer: D

30 Which set of data correctly illustrates titanium as a typical transition metal element and calcium as an s-block element?

	property	titanium	calcium
1	melting point / °C	1668	842
2	Density/ gm cm^{-3}	4.5	1.55

A both 1 and 2
B 1 only
C 2 only
D neither 1 nor 2

Topic: Transition Metals

Concept: Physical properties of transition metals vs s-block elements

Option 1 and 2 are correct as transition metals have higher melting point and density compared to s-block elements. Electrons from 3d and 4s subshell can be delocalised in transition metals, resulting in stronger metallic bonding. Transition metals have smaller radius and higher A_r, resulting in higher density.

Answer: A