Catholic Junior College
JC 2 Preliminary Examinations
Higher 2

CHEMISTRY 9729/01

Paper 1 Multiple Choice **29 August 2017**

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, HT group and NRIC/FIN number on the Answer Sheet in the spaces provided.
Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

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.

MARK SCHEME

For each question there are ***four*** possible answers, ***A***, ***B***, ***C*** and ***D***. Choose the **one** you consider to be correct.

1 When an unknown organic compound is burned completely in excess oxygen, 90 cm^3 of gaseous products is collected. When cooled to room temperature, the gaseous volume decreased to 50 cm^3. A further decrease of 40 cm^3 in the gaseous volume was observed when the gaseous mixture is passed through aqueous potassium hydroxide.

What is the possible identity of the organic compound?

1 CH_2CH_2

2 CH_3CO_2H

3 $CH_3CH_2CH_3$

4 CH_2CHCH_2OH

A 1 and 3 only

B 1 and 4 only

C 1, 2 and 4 only

D 2 and 4 only

Concept: MCS: rxn stoichiometry, molar volume of gas at r.t.p,

Start with volume of CO_2 given and use the equation to work out the mole ratio.

Answer: C

First reduction of gaseous vol due to cooling

→ hot $H_2O(g)$ has condensed to form $H_2O(l)$ at r.t.p.

→ thus, vol of $H_2O(g)$ = 90 – 50 = 40 cm^3

Second reduction of gaseous vol due to reaction with KOH(aq)

→ $CO_2(g)$ is an acidic gas and reacts with KOH(aq) via acid-base reaction

→ vol of $CO_2(g)$ = 40 cm^3

Thus, $CO_2(g)$: $H_2O(g)$ = 40 : 40 = 1 : 1 → Thus, C : H = 1 : 2

Thus the organic compound must have a ratio C : H = 1: 2.

1	CH_2CH_2	→ C_2H_4	→ correct
2	CH_3CO_2H	→ $C_2H_4O_2$	→ correct
3	$CH_3CH_2CH_3$	→ C_3H_8	→ incorrect
4	CH_2CHCH_2OH	→ C_3H_6O	→ correct

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

A vanadium salt of unknown oxidation state was dissolved in water to form a solution of 0.500 mol dm^{-3}. It was found that 20.4 cm^3 of this solution will react with 1.00 g of zinc powder to form vanadium(II) solution.

What is the possible identity of the vanadium salt used?

A V^{2+} **B** V^{3+} **C** VO^{2+} **D** VO_2^+

Concept: Redox: determination of oxidation state

Answer: D

Let the vanadium salt of unknown oxidation state be V^{x+}

Amt of zinc used = 1 ÷ 65.4 = 0.0153 mol

Amt of V^{x+} reacted = $\frac{20.4}{1000}$ × 0.500 = 0.0102 mol

Ratio of Zn : V^{x+} = 0.0153 : 0.0102

= 3 : 2

Given that $Zn \rightarrow Zn^{2+} + 2e^-$,

3 mol of Zn will donate 6 mol of e^- and 2 mol of V^{x+} will accept 6 mol of e^-.

Therefore, 1 mol of V^{x+} will accept 3 mol of e^-.

Since V^{x+} is reduced to V^{2+}, its original oxidation state is +5.

species	V^{2+}	V^{3+}	VO^{2+}	VO_2^+
Oxidation state	+2	+3	+4	+5

Thus, only VO_2^+ is the possible identities of the unknown salt solution.

3 The table below gives some data about four ions.

ions	number of neutrons	number of nucleons
$\mathbf{Q^-}$	16	33
$\mathbf{R^+}$	19	39
$\mathbf{S^{2-}}$	17	33
$\mathbf{T^{2+}}$	18	35

Which of the following pairs consists of ions that are isoelectronic?

A $\mathbf{Q^-}$ and $\mathbf{S^{2-}}$ **C** $\mathbf{S^{2-}}$ and $\mathbf{T^{2+}}$

B $\mathbf{R^+}$ and $\mathbf{S^{2-}}$ **D** $\mathbf{Q^-}$ and $\mathbf{T^{2+}}$

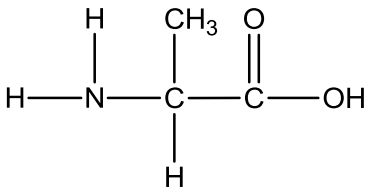
Concept: Atomic Structure: determination of no. of protons and electrons from given species, isoelectronic species

Isoelectronic species have the same number of electrons.

particle	number of neutrons	number of nucleons	number of protons	number of electrons
$\mathbf{Q^-}$	16	33	33 – 16 = 17	17 + 1 = **18**
$\mathbf{R^+}$	19	39	39 – 19 = 20	20 – 1 = 19
$\mathbf{S^{2-}}$	17	33	33 – 17 = 16	16 + 2 = **18**
$\mathbf{T^{2+}}$	18	35	35 – 18 = 17	17 – 2 = 15

ANS: A

4 Which bond angle is present in a molecule of alanine, $H_2NCH(CH_3)CO_2H$, but is **not** present in its zwitterion?



alanine

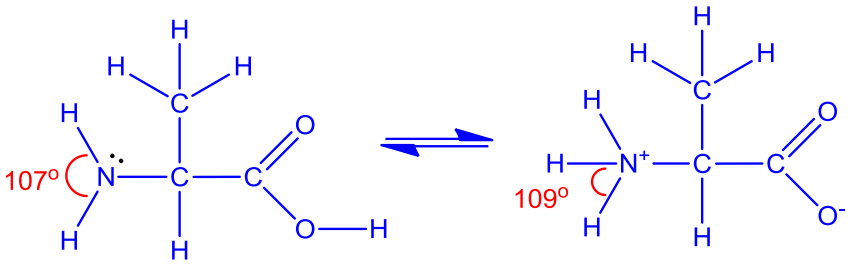
A 90° **B** 107° **C** 109° **D** 120°

Concept: Chemical Bonding: Structure of zwitterion of amino acid

Predict bond angles based on number of bond and lone pairs, and shape around central atom.

Answer: B

Zwitterion of alanine is $^{+}H_3NCH(CH_3)COO^{-}$



alanine

3 bp, 1 lp around N
bond angle = 107°

zwitterion of alanine

4 bp, 0 lp around N
bond angle = 109°

In the zwitterion, $–NH_2$ group (trigonal pyramidal about N, bond angle = 107°) becomes $–NH_3^+$ (tetrahedral about N, bond angle = 109°) and $–CO_2H$ (trigonal planar about sp^2 hybridised carbon, 120°) group becomes CO_2^- (trigonal planar about sp^2 hybridised carbon, 120°).
Option A: bond angle of 90° is not present in both alanine and its zwitterion.

5 What are the types of chemical bonds present in solid phenylammonium chloride, $C_6H_5NH_3Cl$?

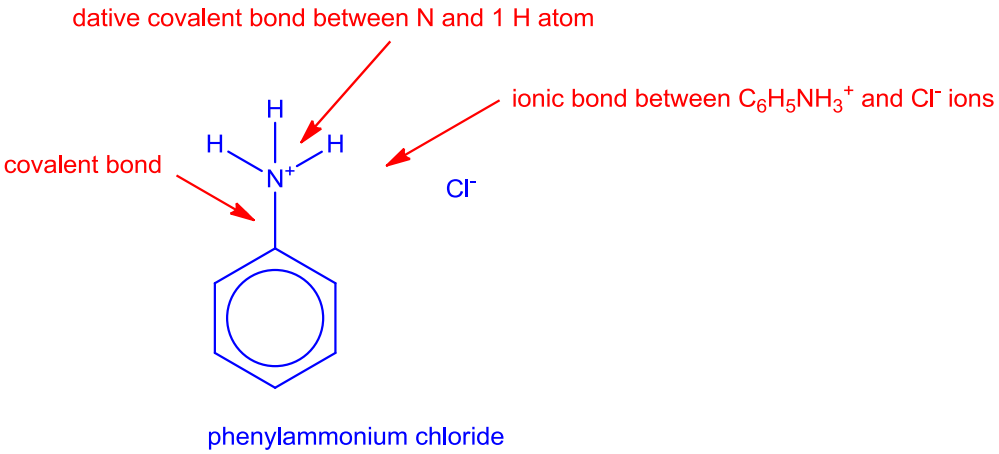
1 dative covalent bonds
2 ionic bonds
3 hydrogen bonds

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

Concept: Chemical Bonding: Identify type of chemical bonds within an ionic compound, consisting of polyatomic ions.

Identify structure to be giant ionic, with covalent bonds within the polyatomic cation, $C_6H_5NH_3^+$

Answer: B



phenylammonium chloride

absence of hydrogen bond; absence of lone electron pair on N

$C_6H_5NH_3Cl$ is an ionic compound, consisting of polyatomic cations, $C_6H_5NH_3^+$ and Cl^-. Hence ionic bonds exist between $C_6H_5NH_3^+$ and Cl^- ions while covalent bond and dative covalent bonds exist between the C, N and H atoms within the $C_6H_5NH_3^+$ cation. Hydrogen bonds are not present as no lone electron pair is present on N atom in $C_6H_5NH_3^+$.

6 Which one of the following shows the standard enthalpy change of formation of carbon monoxide?

A $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

B $C(s) + CO_2(g) \rightarrow 2CO(g)$

C $C(g) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

D $C(g) + CO_2(g) \rightarrow 2CO(g)$

Concept: Chemical Energetics, Definition of enthalpy change of formation.

Answer: A

The **standard enthalpy change of formation,** $\Delta H_f^{\ominus}$, of a substance (usually a compound) is defined as the enthalpy change when one mole of the substance is formed **(Hence options B and D are incorrect as 2 moles of CO are formed)** from its elements under standard conditions of 298 K and 1 bar. (Elements must be in most stable physical form.) **The most stable physical form of carbon is graphite (solid). Hence option C is incorrect and the answer is option A.**

7 Nitrogen dioxide, NO_2, has an unpaired electron and dimerises to form N_2O_4.

$$2NO_2(g) \rightarrow N_2O_4(g)$$

Which of the following statements about the spontaneity of the reaction is true?

A The reaction is only spontaneous at low temperatures.

B The reaction is only spontaneous at high temperatures.

C The reaction is spontaneous at all temperatures.

D The reaction is non-spontaneous at all temperatures.

ΔH of the reaction is negative since the reaction involves bond formation which is exothermic.

ΔS of the reaction is negative as there is a decrease in the number of moles of gaseous particles.

$\Delta G = \Delta H - T\Delta S$
Since ΔH is negative and $-T\Delta S$ is positive, a higher temperature would cause ΔG to become more positive and less spontaneous. Hence the reaction is only spontaneous at low temperatures.

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

Gas canisters used in camping stoves contain partially liquefied hydrocarbon. A canister was connected to a gas syringe and the valve opened slightly to allow some gas into the syringe. 0.200 g of the gas occupied a volume of 96.0 cm^3 at a temperature of 30.0 °C and a pressure of 101 kPa.

What is the average M_r of the gas mixture?

A 31 **B** 52 **C** 479 **D** 519

Concept: Gaseous State; application of Ideal gas equation, pV = nRT & unit conversion

Rearrange pV = nRT equation to solve for M_r

Answer: B

pV = nRT

$= \frac{m}{M_r}RT$ $\therefore M_r = \frac{mRT}{pV} = \frac{(0.200)(8.31)(30+273)}{(101\times10^3)(96.0\times10^{-6})} = 52$

9 At a certain temperature, three gases N_2, O_2 and HC*l* were mixed and the following reaction occurred:

$$2N_2(g) + 3O_2(g) + 4HCl(g) \rightleftharpoons 4NOCl(g) + 2H_2O(g)$$

The initial partial pressures of N_2, O_2 and HC*l* are 0.800 atm, 0.800 atm and 0.400 atm respectively. After equilibrium has been established, it is found that the partial pressure of steam is 0.15 atm.
What is the numerical value of K_p for this reaction at this temperature?

A 1.20 **B** 22.7 **C** 0.0217 **D** 0.0251

Concept: Chemical Equilibria, Finding equilibrium values and calculating K_p, keeping in mind the stoichiometric ratios reacted / formed while achieving equilibrium.

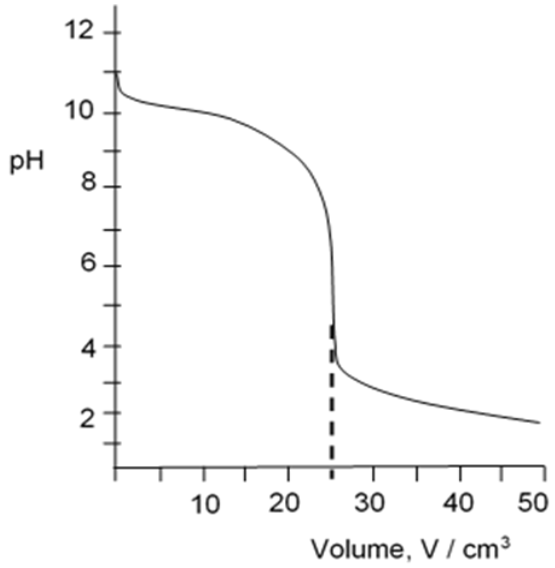
Answer: B
To find the pressures at equilibrium, the ICE table can be drawn.

	$2N_2(g)$	+ $3O_2(g)$	+ $4HCl(g)$	⇌ $4NOCl(g)$	+ $2H_2O$ (g)
Initial p / atm	0.800	0.800	0.400	0	0
Change in p / atm	- (0.15)	-3/2(0.15)	-2(0.15)	+2(0.15)	+0.15
Eqm p / atm	0.65	0.575	0.100	0.300	0.15

$$K_p = \frac{p\mathrm{NOCl}^4\, p\mathrm{H_2O}^2}{p\mathrm{N_2}^2 p\mathrm{O_2}^3 p\mathrm{HCl}^4} = \frac{(0.300)^4(0.15)^2}{(0.65)^2(0.575)^3(0.100)^4} = 22.7\mathrm{atm}^{-3}$$

10 In an acid-base titration, a 0.10 mol dm^{-3} solution of an acid is added to a 25 cm^3 of a 0.10 mol dm^{-3} solution of a base.

The pH value of the solution is plotted against the volume, V, of acid added as shown in the diagram.



Which of the following statements is **incorrect**?

A The titration involved a strong acid and a weak base.

B The pair of solutions could have been HCl(aq) and CH_3NH_2(aq).

C Methyl orange is a suitable indicator for the above titration.

D When concentration of acid is doubled, the end point volume of the titration would be halved while the pH at equivalence point would remain unchanged.

Concept: Chemistry of Aqueous Solutions, interpreting titration curve

Using equivalence point pH to determine type of acid-base reaction

Answer: D

pH at equivalence point < 7; implies presence of acidic salt. Hence strong acid-weak base titration has occurred. Hence Option A is correct.

As the stoichiometry of acid: base = 1:1, hence the solutions involved should be a monoprotic base and a monobasic acid. Hence Option B is correct.

For strong acid-weak base titration, methyl orange is a suitable indicator. Hence Option C is correct too.

When concentration of acid is doubled, the amount of salt formed at equivalence point is fixed though total volume of the solution is now lower.

Compared to $[salt]_{original}$ = 25.0 x 0.1 / (25+25) = 0.05 mol dm^{-3}

$[salt]_{new}$ = 12.5 x 0.2 / (12.5 + 25) = 0.0667 mol dm^{-3}

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

And $[H^+] = \sqrt{Ka} \times [acidic\ salt]$

when [salt] is higher, new $[H^+]$ will work out to be higher, hence new equivalence pH will decrease.

11 The following two reactions are examples of acid-base reactions.

Reaction 1: $HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$

Reaction 2: $NH_3 + BF_3 \rightarrow NH_3BF_3$

Which of the following correctly describes the behaviour of each species?

	Brønsted acid	Brønsted base	Lewis acid	Lewis base
A	HNO_3	NH_3	H_2SO_4	HSO_4^-
B	H_2SO_4	HNO_3	BF_3	NH_3
C	HSO_4^-	NH_3	BF_3	$H_2NO_3^+$
D	$H_2NO_3^+$	HSO_4^-	NH_3BF_3	NH_3

Concept: Definition of Bronsted acids and bases, Lewis acids and bases

For Reaction 1

HNO_3 donated a proton to form $H_2NO_3^+$. HNO_3 is a Brønsted base whereas $H_2NO_3^+$ is the conjugate acid.

H_2SO_4 donated a proton to form HSO_4^- and is a Brønsted acid, whereas HSO_4^- is the conjugate base.

For Reaction 2

NH_3 has a lone pair of electrons on N and donates a pair of electrons to B in BF_3 (which is electron-deficient). NH_3 thus acts as a Lewis base whereas BF_3 acts as the Lewis acid.

12 The decomposition of hydrogen peroxide is known to be a first order reaction.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The rate constant is found to be 4.95 x 10^{-2} min^{-1}. If the initial concentration of H_2O_2 is 4.00 mol dm^{-3}, what will be the concentration of H_2O_2 after 64 min?

A 0.50 mol dm^{-3}

B 0.20 mol dm^{-3}

C 0.17 mol dm^{-3}

D 0.13 mol dm^{-3}

Concept: Calculations involving first order reactions, making use of the formula t1/2 = ln 2 / k

Half life = ln 2 / (4.95 x 10^{-2}) = 14 min
Number of half-lives = 64 / 14 = 4.57

$$\frac{Ct}{Co} = (\frac{1}{2})^n$$

$$\frac{Ct}{4} = (\frac{1}{2})^{4.57}$$

C_t = 0.168 mol dm^{-3}

13 The rate equation for the reaction 2**W** + **X** → **Y** + **Z** is given as rate = k[**W**][**X**]. In an experiment to study the kinetics of the reaction, the initial concentration of **W** used is 0.20 mol dm^{-3} and the initial concentration of **X** used is 0.001 mol dm^{-3}.

Which of the following statements regarding the experiment is correct?

A The half-life for the [**X**] against time curve is approximately constant.

B The mechanism for the above reaction involves one step.

C The units of the rate constant is $mol^{-2}dm^6s^{-1}$.

D Doubling the initial concentration of **W** to 0.40 mol dm^{-3} will not affect the half-life of **X**.

Concept: relationship of mechanism to rate equation and overall equation, interpretation of units for rate constant

The concentration of **W** is 200 times larger than **X**, hence the reaction is pseudo zero order wrt **W** and the reaction becomes overall pseudo first-order.

Rate = k' [**X**], where k' = k [**W**]

Therefore half-life of **X** will be approximately constant having a value of $t_{½} = \frac{\ln 2}{0.2\ k}$

D: when initial [**W**] is doubled, $t_{½}$ will be halved.

B: Since stoichiometry shows that 2 W are involved, the reaction will have more than one step as the slow step involves only 1W and 1X leaving the other W molecule/ion to be involved in the fast step.

C: Since rate = k[**W**][**X**], and units of rate = $moldm^{-3}s^{-1}$, the units for k = $mol^{-1}dm^3s^{-1}$

14 The oxide and chloride of an element **E** are mixed separately with water. The two resulting solutions have the same effect on litmus.

What is element **E**?

A Mg **B** Al **C** Si **D** P

Concept: Trends across Period 3, and oxides and chlorides of Period 3

Answer: D
For Option B and C
Note that both SiO_2 and Al_2O_3 are insoluble in water. The resulting solution would thus be neutral. Both $SiCl_4$ and $AlCl_3$ will give undergo hydrolysis to give acidic solutions.

PCl_5 undergoes hydrolysis to form H_3PO_4 and HCl, which causes the resulting solution to be acidic and turn blue litmus red. P_4O_{10} would also undergo hydrolysis to give H_3PO_4 which is an acidic solution.

MgO is gives $Mg(OH)_2$ in water which is weakly basic whereas $MgCl_2$ is weakly acidic.

15 Which of the following statements about iodine or its compounds are correct?

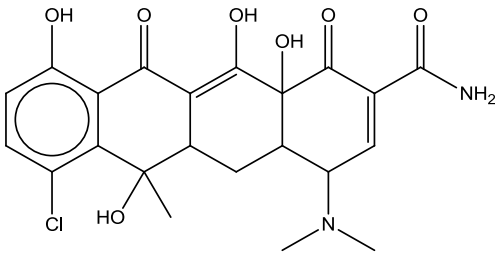
1 A crystal of iodine contains covalent bonds and instantaneous dipole-induced dipole forces of attraction.
2 When aqueous chlorine is added to potassium iodide and the aqueous mixture shaken with tetrachloromethane, a purple organic layer is obtained.
3 The first ionisation energy of iodine is less than that of bromine.
4 The thermal stability of hydrogen iodide is higher than that of hydrogen bromide.

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

Concept: Group 17 Halogen and Halide properties

1: I_2 is a non-polar simple covalent molecule. Thus, there are strong covalent bonds between I atoms and instantaneous dipole-induced dipole forces of attraction between iodine molecules.
2: Cl_2 can oxidise KI to form I_2 which is purple in the organic layer.
Ecell = 1.36 – 0.54 > 0 V (thus the reaction is spontaneous)
3: Ionisation energy decreases down the group. I_2 has a lower first ionisation energy than Br_2.
4: H- I bond is longer and weaker than H-Br and thus HI has a lower thermal stability.

16 *Aureomycin* is a powerful oral antibiotics that is effective against a wide range of infections.



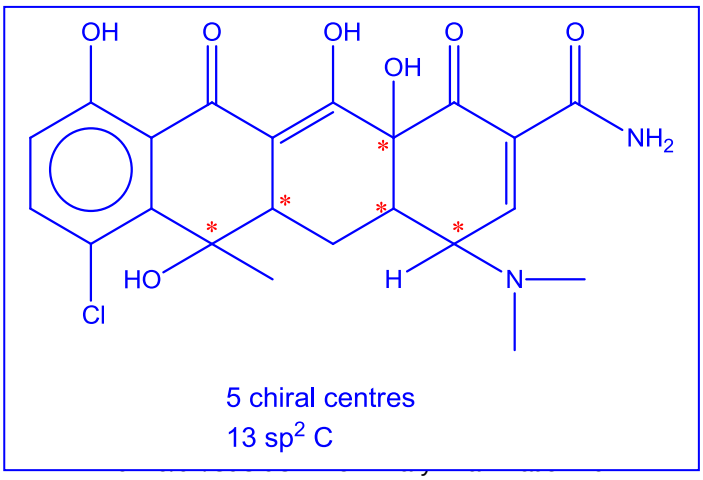
Aureomycin

Which row correctly indicates the number of chiral centres and sp^2 hybridised carbon in a molecule of *aureomycin*?

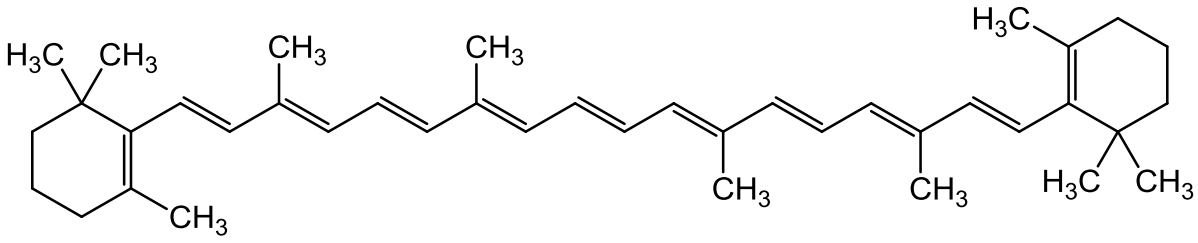
	Number of chiral centres	Number of sp^2 hybridised C
A	4	10
B	4	13
C	5	10
D	5	13

Concept: Introduction to Organic Chem; identification of chiral C & hybridisation

Answer: D



17 β-carotene is responsible for the orange colour of carrots.



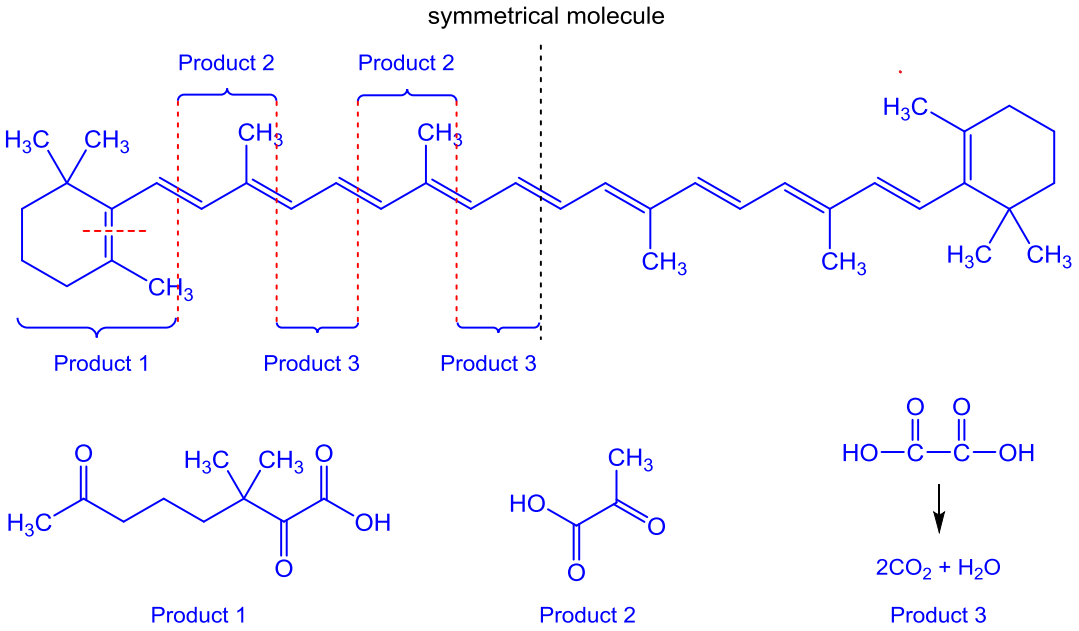
β–carotene

β-carotene is oxidised by hot, concentrated, acidified $KMnO_4$.

How many different products formed from the above reaction contain the ketone functional group?

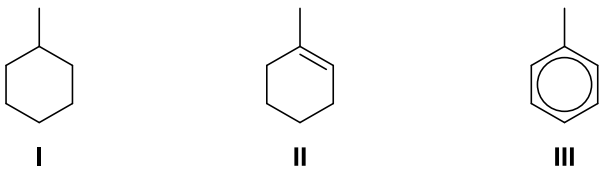
A 2 **B** 4 **C** 6 **D** 8

Concept: oxidative cleavage of C=C and identifying the ketone functional group



Since the molecule is symmetrical, there are only 2 different products that contained ketone groups.

18 Which of the statements are true regarding the three compounds below?



I II III

1 Compounds **I** and **III** will not decolourise Br_2 in CCl_4.

2 Compounds **I** and **II** will decolourise acidified $KMnO_4$ at 298 K.

3 Compound **III** will not react with chlorine in the presence of uv light.

4 Compound **III** will react with bromine in the presence of a homogeneous catalyst.

A 1 and 4 only

B 2 and 3 only

C 1, 3 and 4 only

D 1, 2, 3 and 4

Concept: Chemical properties of Hydrocarbons

Reagents and conditions of Free Radical Substitution, Electrophilic Addition and Electrophilic Substitution

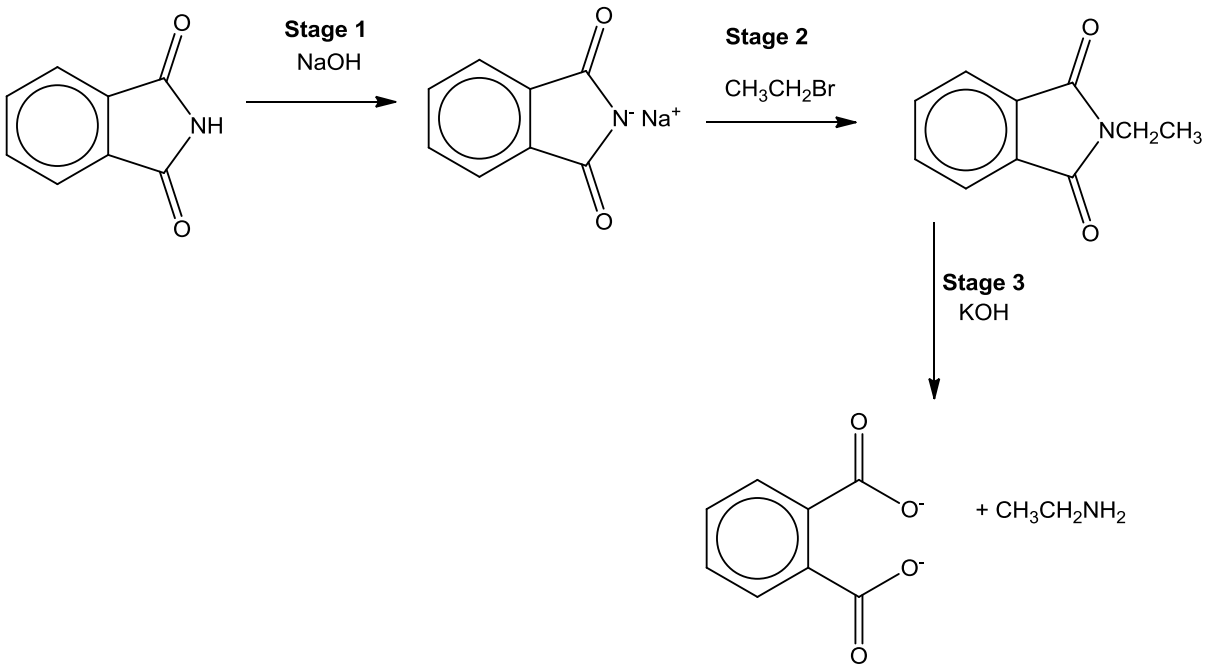
addition. Thus, both compounds **I** and **III** will not decolourise Br_2.

Statement 2: False. Compound **I** will not decolourise purple $KMnO_4$ at room temp.

Statement 3: False. The alkyl side-chain of compound **III** will be able to undergo free radical substitution with Cl_2 gas when exposed to uv light.

Statement 4: True. Compound **III** requires $FeBr_3$ catalyst for electrophilic substitution to occur.

19 A sequence of reactions is shown below.



Which of the following correctly describes the type of reactions for Stages **1** to **3**?

	Stage 1	Stage 2	Stage 3

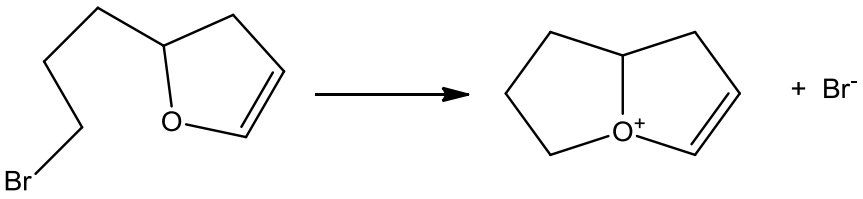
A	neutralisation	electrophilic substitution	nucleophilic substitution
B	hydrolysis	nucleophilic substitution	hydrolysis
C	redox	nucleophilic addition	nucleophilic substitution
D	neutralisation	nucleophilic substitution	hydrolysis

Concept: identifying types of reaction for organic compounds

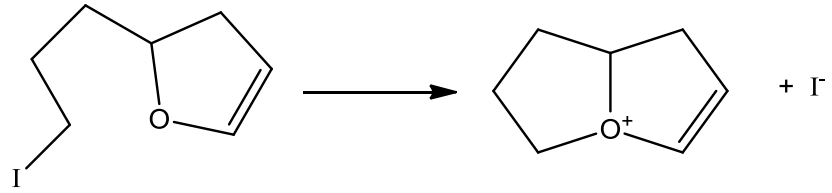
Stage 1: The diamide donated a proton and is a Bronsted acid. The OH^- accepted a H^+ to form H_2O. Thus this is an acid-base reaction.
Stage 2: Bromoethane undergoes nucleophilic substitution, with the negatively charged ion acting as the nucleophile.
Stage 3: The amide undergoes base-catalysed hydrolysis.

20 The intramolecular reactions below occur via nucleophilic substitution mechanism.

Reaction 1



Reaction 2



Reaction 2 is faster than reaction 1 under identical conditions.

Which statement explains this difference?

A Br is more electronegative than I.

B The I^- ion is a stronger nucleophile than Br^-.

C The C–Br bond is more polar than the C–I bond.

D The C–Br bond is stronger than the C–I bond.

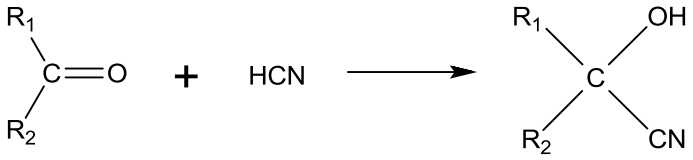
Concept: Halogen Derivatives; effect of C-Hal bond strength on reactivity towards nucleophilic substitution

To recall weaker C-Hal bond leads to faster substitution by nucleophile

Answer: D

C-Br bond is stronger than C-I bond, hence rate of S_N2 nucleophilic substitution in reaction 1 is slower.

21 Cyanohydrins can be made from carbonyl compounds by generating CN^- ions from HCN in the presence of a weak base.



In a similar reaction, $^-CH_2COOCH_3$ ions are generated from CH_3COOCH_3 by strong bases.

Which compound can be made from an aldehyde and CH_3COOCH_3?

A $CH_3CH(OH)COOCH_3$
B $CH_3COOCH_2CH(OH)CH_3$
C $CH_3CH_2CH(OH)CH_2COOCH_3$
D $(CH_3)_2C(OH)CH_2COOCH_3$

Concept: Pattern identification and interpreting condensed structural formula

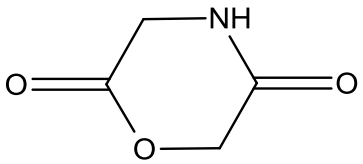
A is incorrect. The nucleophile used is $^-COOCH_3$.

B is incorrect. The nucleophile used is $CH_3COOCH_2^-$.

C is correct. The nucleophile used is $^-CH_2COOCH_3$ and it reacts with an aldehyde CH_3CH_2CHO.

D is incorrect. The nucleophile used is $^-CH_2COOCH_3$ but it reacts with a ketone CH_3COCH_3

22 The cyclic compound **X** is heated with acidified $KMnO_4$.



Compound **X**

What are the final organic products of the reaction?

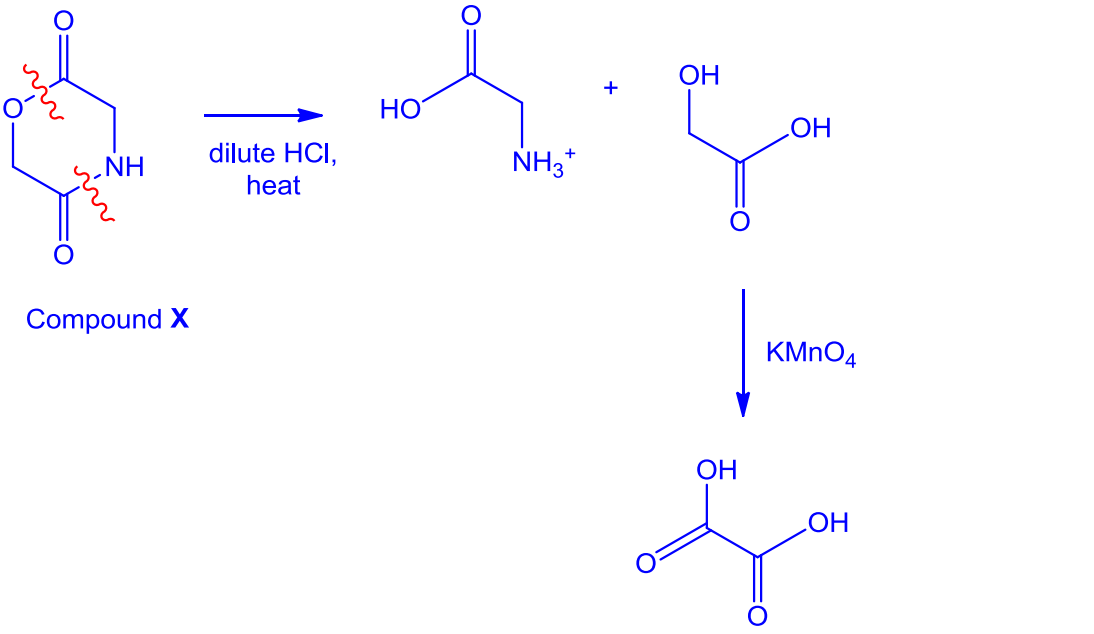
A $HOCH_2CO_2H$ and $HO_2CCH_2NH_3^+$

B $HO_2CCH_2NH_3^+$

C $HOCH_2CHO$ and $H_2NCH_2CO_2H$

D H_2NCOCH_2OH and $HOCH_2CHO$

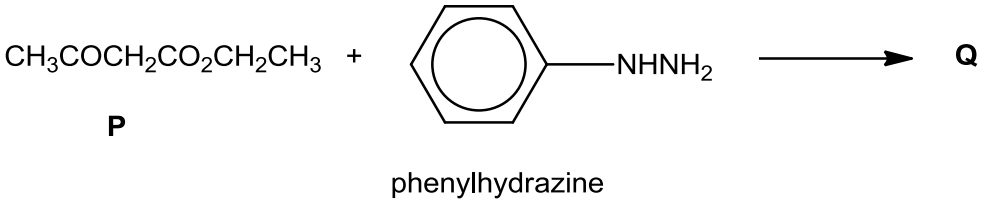
Concept: hydrolysis of amides and esters



Compound **X**

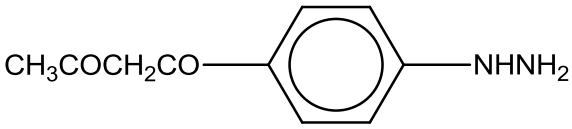
ethanedioic acid undergoes further oxidation to give CO_2 and H_2O

23 The first stage in the synthesis of *Antipyrine,* a fever medication, is the reaction between compound **P** and phenylhydrazine.

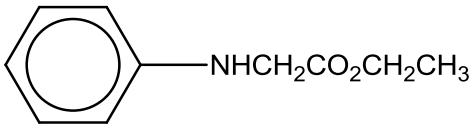


Which of the following correctly represents the structure of product **Q**?

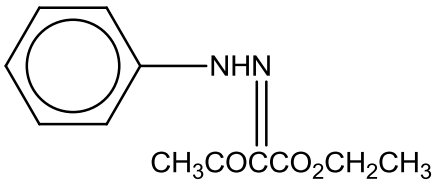
A



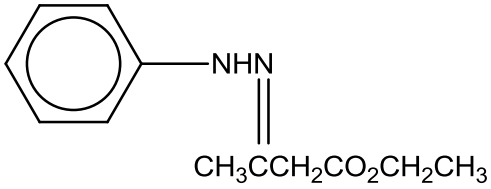
B



C



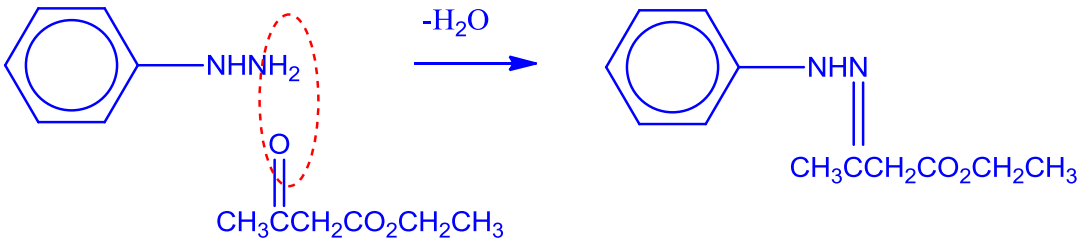
D



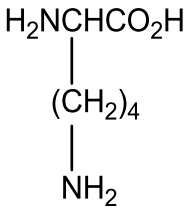
Concept: Carbonyl Compounds & Carboxylic acids derivatives

Predicting product formed from condensation reaction between a ketone and phenylhydrazine (extension of knowledge from reaction between carbonyl compounds and 2,4-DNPH.

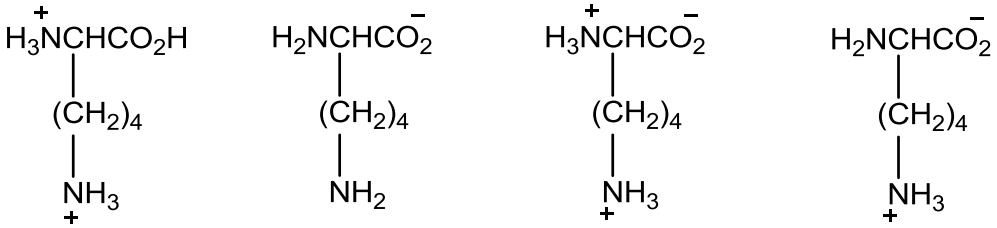
Answer: D



24 Lysine is an α-amino acid.



Which structure is predominant when lysine is in an aqueous solution of pH 9.5, given that lysine has three pK_a values of 2.2, 8.9 and 10.5?



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

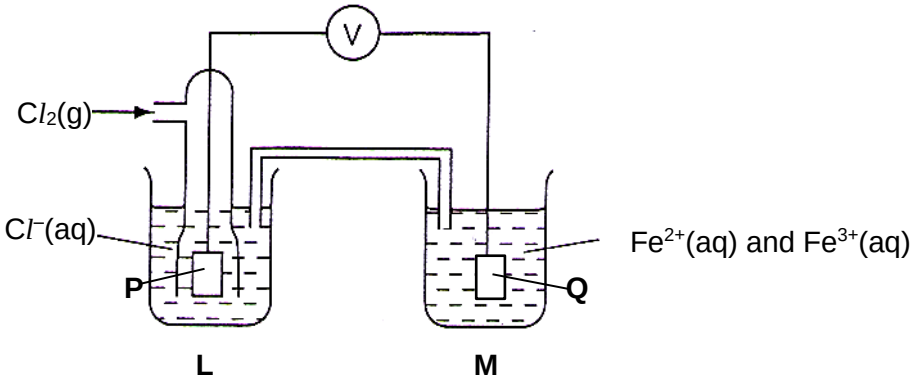
Concept: Nitrogen Compounds; assigning pK_a values, determining predominant structure of amino acid in alkaline solution.

Answer: D

Side-chain -NH_3+ group will not dissociate as its pK_a value (10.5) is above pH 9.5.

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

The cell shown below is set up under standard conditions where **P** and **Q** are platinum electrodes.



Which of the following statements is correct?

A Addition of KCN to half-cell **M** will not affect $E_{cell}^{\ominus}$.

B The voltmeter will show a reading of about 2.13 V.

C The electrons will flow from **Q** to **P** through the voltmeter.

D **P** will be the negative electrode.

Concept: Electrochemical cell setup, determining cell emf.

Answer: C

A. Wrong. By introducing CN^- Ligands, the $E(Fe^{3+}/Fe^{2+})$ changes and therefore the cell emf will change. , it will participate in reaction.

B. Wrong. Cell emf = 1.36 – 0.77 = 0.59 V

C. Correct. Half-cell **M** is undergoing oxidation (loss of electrons) since the $E(Fe^{3+}/Fe^{2+})$ is less positive than $E(I_2/I^-)$.

D. Wrong. In electrochemical cell, the half-cell where reduction takes place, the electrode will have positive polarity. Oxidation is taking place in half-cell **M**.

26 During electroplating, a current is passed through a cell containing aqueous silver nitrate using inert electrodes. After some time, 1.35 g of silver was deposited at one electrode. What volume of gas would be produced at the other electrode at r.t.p.?

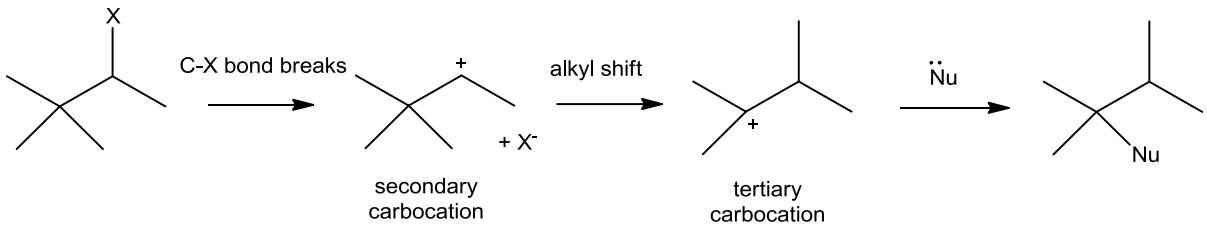
A 70 cm^3 **B** 75 cm^3 **C** 140 cm^3 **D** 150 cm^3

Concept: Electrolytic calculations via half-cell reactions.

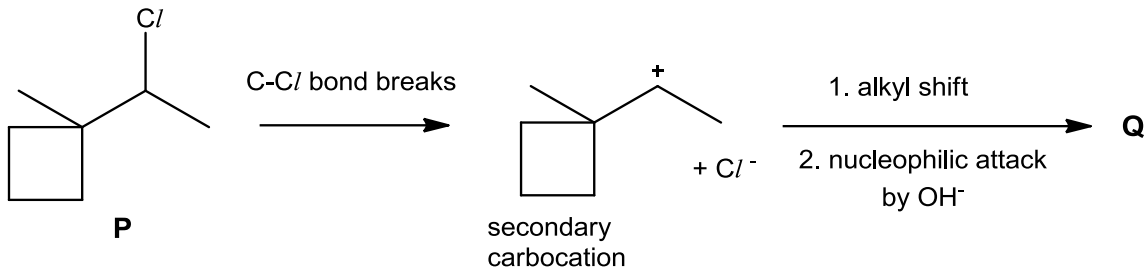
Answer: B

$Ag^+ + e^- \rightarrow Ag$ is formed at the cathode
1 mol of Ag requires 1 mol of electrons
No. of mole of electrons = 1.35/108 = 0.0125 mol
$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
1 mol O_2 give 4 mol of electrons
No. of mole of oxygen formed = 0.0125/4 = 0.003125 mol
Volume of oxygen = 0.03125 x 24000 = 75 cm^3

27 In S_N1 reactions involving secondary halogenoalkanes, alkyl shift can sometimes occur after the breaking of C–X bond to form a more stable tertiary carbocation.

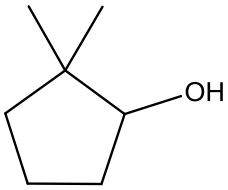


Rearrangements need not always involve methyl groups. In situation when the carbocation is formed adjacent to a strained ring, such as a cyclobutane, it is more favourable for one of the alkyl groups in the ring, rather than the methyl group, to shift so as to cause **ring expansion** and the formation of a less strained ring.

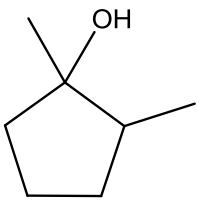


Which of the following is a possible identity of **Q**?

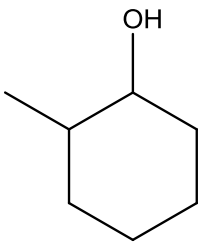
A



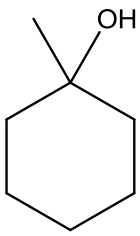
B



C

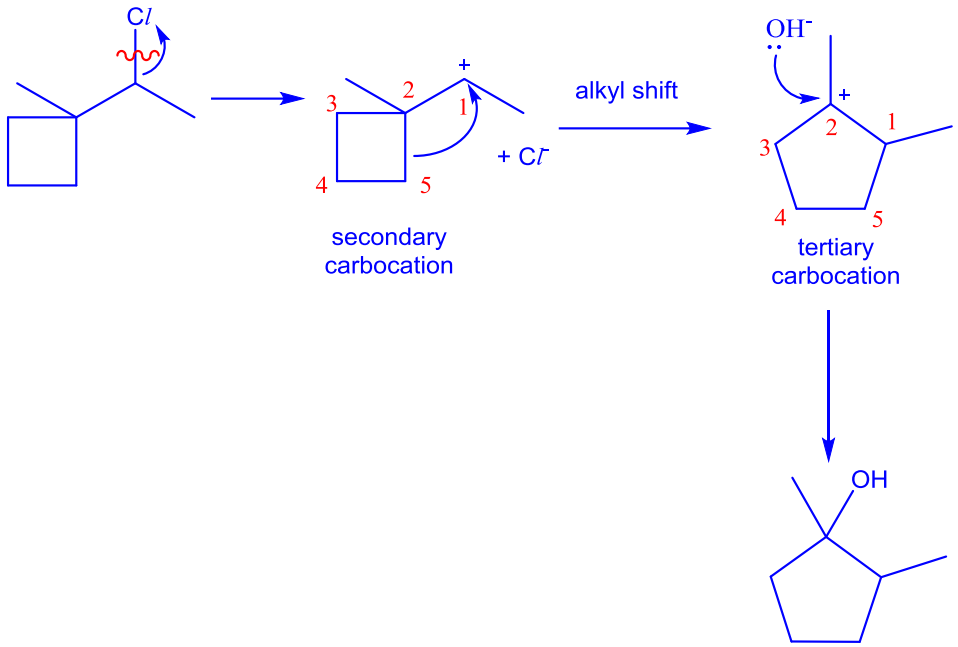


D

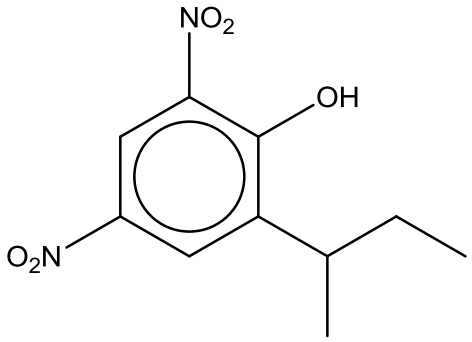


Concept: Pattern recognition of novel reaction; predicting structure of product

Answer: B



28 *Binapacryl* is used as a fungicide.



Binapacryl

Which of the following statements about *Binapacryl* are correct?

1 It dissolves in water to give a neutral solution.
2 It is inert towards acidified potassium dichromate(VI) solution.
3 It decolourises aqueous bromine to form a white precipitate.
4 It reacts with ethanoic acid in the presence of concentrated sulfuric acid to form an ester.

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

Concept: Hydroxy compounds (phenols); reactions of phenols; chirality.

Answer: A

1 It dissolves in water to give a neutral solution. **False; Binapacryl is not soluble in water.**

2 It is inert towards acidified potassium dichromate solution. **True; acidified $K_2Cr_2O_7$ is not strong enough to oxidise the alkyl side-chain.**

3 It decolourises aqueous bromine to form a white precipitate. **False; phenolic group in Binapacryl is already 2, 4 substituted. Hence will not be able to undergo further electrophilic substitution with aq. Br_2.**

4 It reacts with ethanoic acid in the presence of concentrated sulphuric acid to form an ester. **False; phenol and ethanoic acid are both weak acids; no reaction between both compounds. To form ester with phenol, acyl chloride is required instead.**

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

The reaction between peroxodisulfate(VI) ion, $S_2O_8^{2-}$, and tartrate ion, $[CH(OH)CO_2^-]_2$, is slow due to a high activation energy.

The reaction can be catalysed by a homogeneous catalyst.
Given that

$$2CO_2 + 2HCO_2^- + 6H^+ + 6e^- \rightleftharpoons \text{HO—C(H)—CO}_2^- \text{ (HO—C(H)—CO}_2^-\text{)} + 2H_2O \qquad E^\ominus = +0.56\ V$$

Which metal ion is **not** a suitable catalyst for this reaction?

A Co^{2+}

B Cr^{2+}

C Mn^{3+}

D Fe^{3+}

Concept tested: Transition metal ions as suitable homogeneous catalyst

From data booklet, $E^\ominus$ ($S_2O_8^{2-}$ / SO_4^{2-}) = +2.01V
Hence $E^\ominus$ value of suitable catalyst should be between +0.56 V and +2.01 V

$E^\ominus$ (Co^{3+}/Co^{2+}) = +1.89 V
$E^\ominus$ (Mn^{3+}/Mn^{2+}) = +1.54 V
$E^\ominus$ (Fe^{3+}/Fe^{2+}) = +0.77 V
$E^\ominus$ (Cr^{3+}/Cr^{2+}) = -0.41 V

Hence Cr^{3+} is not a suitable catalyst for this reaction.
Answer: B

30 Chromium forms a series of compounds with the general formula $CrCl_3 \bullet 6H_2O$. One of these compounds, **X** is violet and produces an aqueous solution from which all the chlorine can be precipitated as AgC*l* upon addition of aqueous silver nitrate.
Another compound **Y** is green and produces an aqueous solution from which only one third of the chlorine can be precipitated with silver nitrate.

Which of the following statements about **X** and **Y** is **incorrect**?

A **X** is an ionic compound consisting of $[Cr(H_2O)_6]^{3+}$ and Cl^- ions.

B **Y** is an ionic compound consisting of $[Cr(Cl)_2(H_2O)_4]^+$ and Cl^- ions.

C Oxidation number of Cr in **X** is +3 while the oxidation number of Cr in **Y** is +1.

D Oxidation number of Cr in **X** and **Y** remains unchanged during precipitation of AgC*l*.

Concept: Introduction to Transition Elements; complex ion formation and oxidation number of central metal ion.

Determining formula of Cr-containing complex ions and oxidation number of central metal ion based on given information.

Answer: C

A **X** is an ionic compound consisting of $[Cr(H_2O)_6]^{3+}$ and Cl^- ions. **True; since all chlorine can be precipitated, it implies all chlorine exists as free Cl- ions in the aqueous solution.**

B **Y** is an ionic compound consisting of $[Cr(Cl)_2(H_2O)_4]^+$ and Cl^- ions. **True; since only 1/3 of the chlorine can be precipitated, it implies 2/3 of the chlorine are bonded to the Cr in the complex ion.**

C Oxidation number of Cr in **X** is +3 while the oxidation number of Cr in **Y** is +1. **False; Oxidation number of Cr in both X and Y is +3.**

D Oxidation number of Cr in **X** and **Y** remains unchanged during precipitation of AgC*l*; **True; precipitation is not a redox reaction.**