Worked Solutions for SAJC 2013 Prelim Exam Paper 1

1 The metal, **M** (A_r = 52.8), combines with 1.2 g of oxygen to form the oxide $\mathbf{M}_2O$. The metal, **M**, also forms a second oxide in which the metal and oxygen are present in the ratio 14:1 by mass.

What is the molecular formula of the second oxide?

A M_2O_3 **B** M_4O

C $M_{11}O_3$ **D** M_7O

In M_2O

For 2nd oxide, assuming 15g of oxide,

1 g of O = 0.0625 mol

14 g of M = 0.265 mol

Ratio of M:O is 0.265:0.0625 → 4.24:1

Ratio is 4.24:1.

Ans: B

2 0.0100 mol of an oxide of an element, **L**, represented by $\mathbf{L}_2O_n$ is found to react with exactly 8.00 x 10^{-3} mol of acidified $KMnO_4$ solution. In the reaction, aqueous $H\mathbf{L}O_4^{2-}$ ion is formed. What is the initial oxidation state of **L**?

A + 1 **B** + 2

C + 3 **D** + 4

L is oxidised to HLO_4^{2-}, MnO_4^- is reduced. L loses electrons.

Amt of $KMnO_4$ used = 8.00 x 10^{-3} mol

Amt of electrons donated by L = 0.04 mol

Amt of L atoms = 0.01 x 2 = 0.02 mol

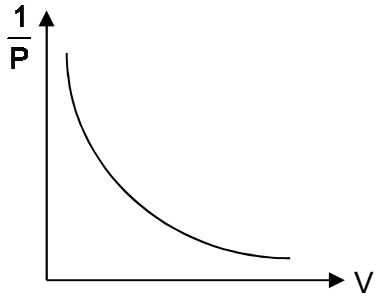
Ratio of electrons donated : L is 0.04:0.02 → 2:1

Each L has its oxidation state increased by +2. L has final oxidation state of 5+ in HLO_4^{2-}, so initial oxidation state should be +3.

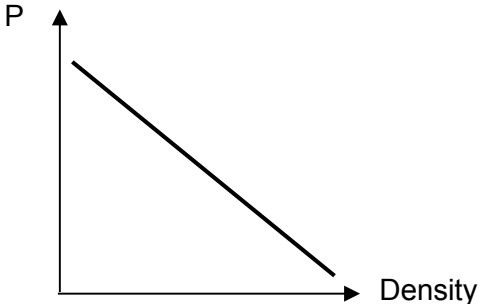
Ans: C

3 Which of the following diagrams correctly describes the behavior of a fixed mass of an ideal gas at constant *T*? (*T* is measured in K.)

A

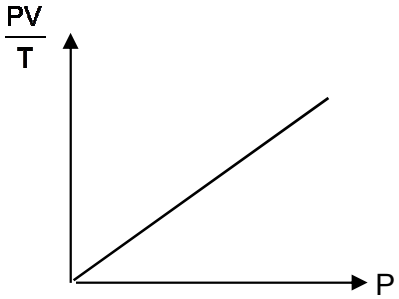


C



B

D



Ans: B. PV = nRT, so for a fixed mass of gas, the value of nRT is constant and does not change on the graph regardless of the value of V.

4 With reference to its electronic configuration, which of the following statements is true about the electrons in the atoms of the element with atomic number 29?

A The electrons in the outermost principle quantum shell experience inter-electronic repulsion.

B The d electrons are in the same principle quantum shell as the outermost s electrons.

C There are p electrons in 2 different principle quantum shells.

D There are s electrons in 3 different principle quantum shells.

Element with atomic number 29 is copper Cu.

A is not true because the only electrons in the outermost principal quantum shell are the 4s electrons – there is no inter-electronic repulsion in 4s orbital.

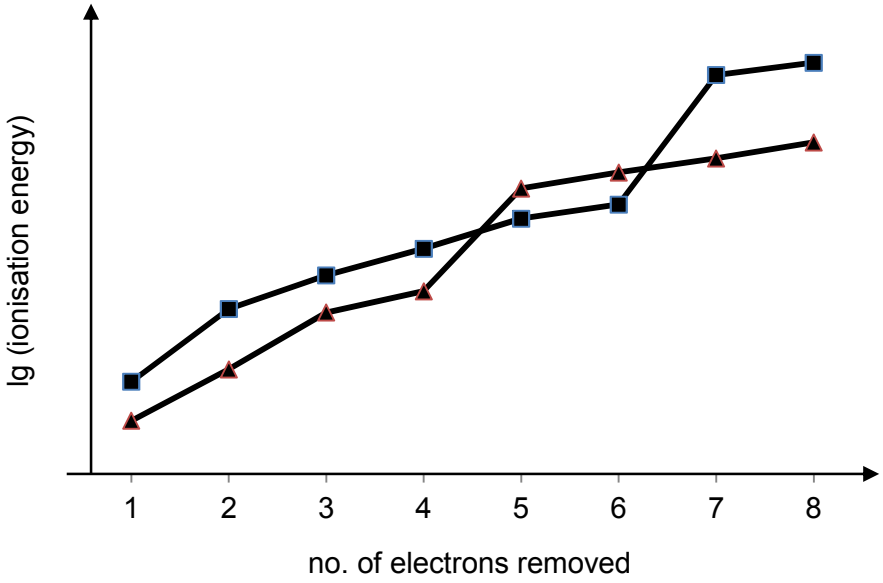
B is not true as the electrons are in 3d and 4s orbitals.

C is true as there are electrons in the 2p and 3p subshells.

D is not true as there are electrons in the 1s, 2s, 3s, and 4s subshells.

Ans: C

5 The graph shows the logarithm, lg, of the first eight ionisation energies of two elements in Periods 2 and 3.



What is the most likely compound that will be formed between the two elements?

A CO_2 **B** SiO_2 **C** CS_2 **D** $SiCl_4$

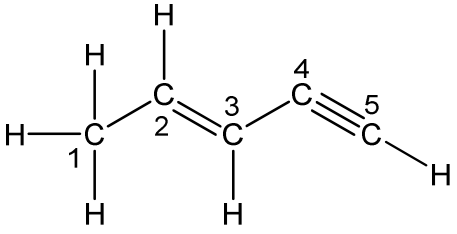
The graph shows two lines. One line (triangle markers) shows a jump from 4 to 5, which means the 5th electron removed needs high IE, so it is from an inner shell. Hence, it is a group IV element.

The other line (square markers) shows a jump from 6 to 7, which means the 7th electron removed needs high IE, so it is from an inner shell. Hence, it is a group VI element.

The group 4 element shows a lower IE for the first 4 electrons removed than the group 6 element, so this indicates that the group IV element lies lower on the Periodic table, so it should be from Period 3 – it is silicon. The group VI element is from period 2 – it is oxygen.

The compound is therefore SiO_2. Ans: B

6 Covalent bonds are formed by orbital overlap. Which of the following is not present in the following molecule?



A sp^3-sp^2 overlap between C1 and C2

B sp^2-sp^2 overlap between C2 and C3

C sp^3-sp overlap between C3 and C4

D sp-sp overlap between C4 and C5

Hybridisation state of each carbon:

C1 – sp^3

C2 – sp^2

C3 – sp^2

C4 – sp

C5 – sp

Option C states a sp^3-sp overlap between C3 and C4, and C3 is definitely not sp^3.

Ans: C

7 Which of the following molecules is planar?

A Benzene **– planar**

B SCl_6 **– octahedral**

C Butanone **– has carbons in tetrahedral arrangement**

D Cyclohexene **– has carbons in tetrahedral arrangement**

Ans: A

8 Given the following enthalpy changes:

Enthalpy change of atomisation of carbon	= +715 kJ mol^{-1}
Enthalpy change of atomisation of oxygen	= +248 kJ mol^{-1}
Enthalpy change of combustion of carbon	= -394 kJ mol^{-1}

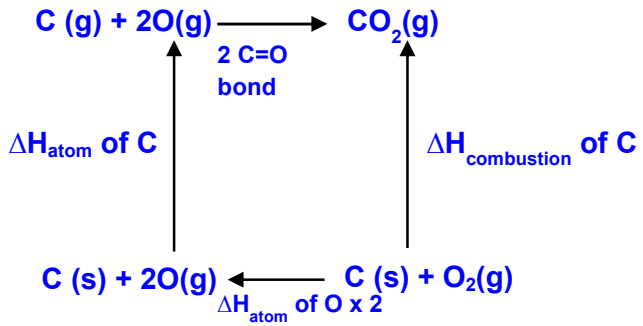
What is the bond energy of the C=O bond?

A 617 kJ mol^{-1}

B 679 kJ mol^{-1}

C 740 kJ mol^{-1}

D 803 kJ mol^{-1}



Using Hess' Law, clockwise = anti-clockwise

-394 = (+248 x 2) + (+715) + [B.E. of C=O x 2]

[B.E. of C=O] = 802.5 $kJmol^{-1}$

Ans: D

9 The enthalpy changes of formation of gaseous oxides of nitrogen are positive. Which of the following statements accounts for the positive enthalpy changes?

A Oxygen has a high tendency to form O^{2-} ions.

B Oxygen and nitrogen have similar electronegativity.

C Nitrogen has high ionisation energies.

D The nitrogen molecule has a high bond energy.

A is not correct though it is true, because a high tendency actually means the process is less exothermic (negative enthalpy change). Also, the oxides are covalent, not ionic.

B is not correct though it is true, because electronegativity has no effect on enthalpy change here.

C is not correct though it is true, because the oxides of nitrogen are covalent and do not involve ionisation.

D is correct and true because the N≡N bond requires more energy to break, hence the overall reaction is endothermic (positive energy change)

Ans: D

10 The equation below represents a monomer-dimer system:

$$2NO_2\ (g) \underset{k_b}{\overset{k_f}{\rightleftharpoons}} N_2O_4\ (g) \qquad \Delta H < 0$$

brown colourless

Which statement about the equilibrium is correct?

A k_f increases and k_b decreases when the equilibrium mixture is heated.

B Increasing the temperature decreases the equilibrium constant K_c.

C Addition of argon at constant volume shifts the equilibrium position to the right.

D Addition of a catalyst will increase the colour intensity of the mixture.

A is not correct because rate constants always increase when temperature increases.

B is correct as the enthalpy change is negative – when temperature increases, the system will counter by absorbing heat, favouring the endothermic reaction. In this case, the endothermic reaction is backwards. Hence equilibrium shifts left, and the concentration of reactants increases while the concentration of products decreases → the equilibrium constant value decreases.

C and D are not correct as the addition of catalyst has no effect on the equilibrium and do not result in more products or reactants formed.

Ans: B

11 A 1:3 molar mixture of X_2 and Y_2 is heated at 673 K and 100 atm of constant pressure so that it comes to equilibrium. The equilibrium mixture contains 20 % of XY_3.

$$X_2(g) + 3Y_2(g) \rightleftharpoons 2XY_3(g)$$

Using the equation above, what is the numerical value of K_p for the reaction at 673 K?

A 9.26×10^{-5}

B 2.93×10^{-4}

C 2.50×10^{-4}

D 5.68×10^{-4}

As this is a chemical equilibria question, an ICE table is required.

But as pressure is constant throughout, the units for the ICE table cannot be pressure, particularly so in this case when the number of gases on each side of the equilibrium are not the same. The units for the table therefore has to be in mol.

Let amount of XY_3 formed be 2a.

	$X_2(g)$ +	$3Y_2(g) \rightleftharpoons$	$2XY_3(g)$	Total mol	Pressure
Initial/mol	1	3	0	4	100
Change/mol	-a	-3a	+2a		100
Eq/mol	1-a	3-3a	2a	4-2a	100
Eq/mol (after solving a)	2/3	2	2/3	3.33 or 10/3	

Since the equilibrium mixture contains 20% of XY_3, therefore

$$\frac{2a}{4-2a} = 20\% = 0.2$$

Solving for a, a = 1/3

Find partial pressure of each gas,

P_{x2} = 20atm

P_{Y2} = 60atm

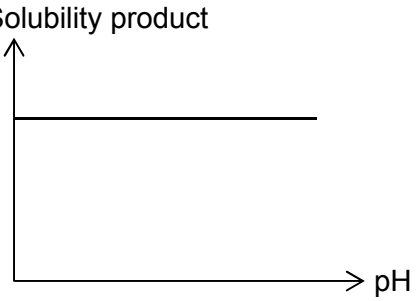
P_{XY3} = 20atm

$K_p = \frac{P_{XY_3}{}^2}{P_{x_2} P_{Y_2}{}^3}$ = 9.26 x 10^{-5}

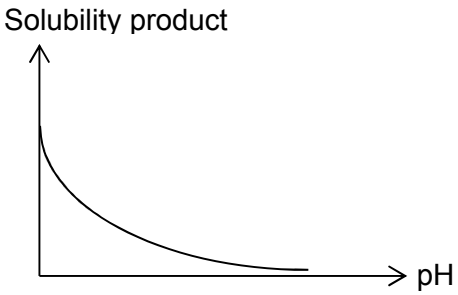
Ans: A

12 The numerical value of the solubility product of copper (I) iodide is 1.27×10^{-12}. Given that HI is a strong acid, which diagram shows how the solubility product of CuI will vary with pH at constant temperature?

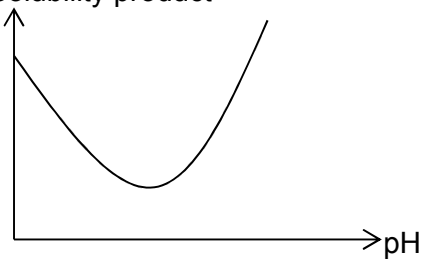
A



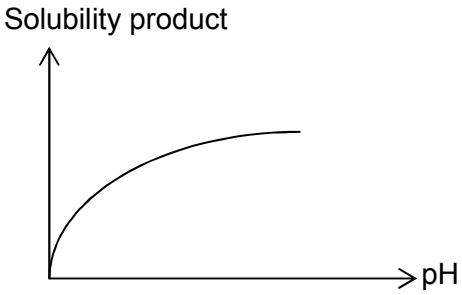
C



B



D



Ans: A – solubility product is only affected by change in temperature

13 At 298 K, the numerical values for the dissociation constant of the aliphatic carboxylic acids, **R**CO_2H and **R'**CO_2H in aqueous solution are 4.8×10^{-6} and 3.6×10^{-3} respectively. Which of the following statements is true?

A **R**CO_2^- is a weaker base than **R'**CO_2^-.

B The volume of 1.0 mol dm^{-3} H_2SO_4 used to neutralize **R**$CO_2^-Na^+$ completely is lower than that for **R'**$CO_2^-Na^+$.

C A buffer solution is formed when 20 cm^3 of 0.01 mol dm^{-3} KOH is mixed with 10 cm^3 of 0.1 mol dm^{-3} **R**COOH.

D 0.10 mol dm^{-3} of **R'**COOH has a higher pH than 0.10 mol dm^{-3} of aqueous **R'**$CO_2^-Na^+$.

A is not true. R'CO_2H is a weaker acid than RCO_2H as it has a lower dissociation constant. Therefore, its conjugate base is stronger than the conjugate base of RCO_2H.

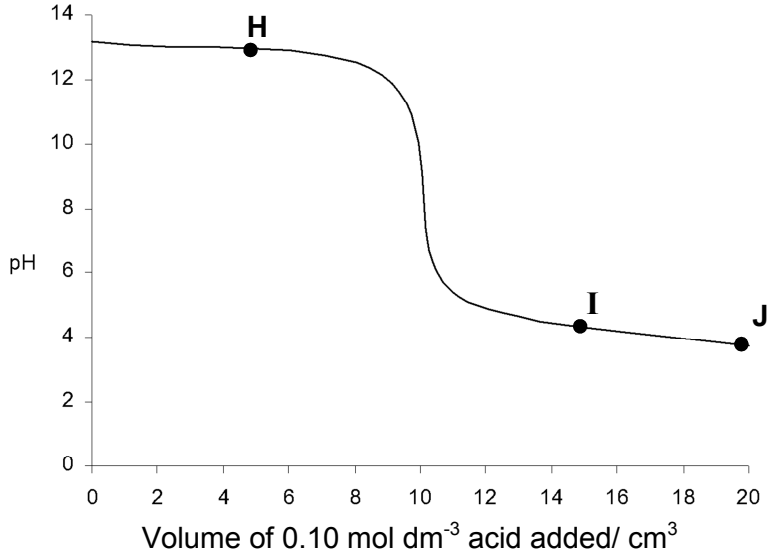
B is not true. Amount of acid to neutralise a base not affected by dissociation constant.

C is true. KOH does not neutralise RCOOH completely, forming a mixture of the weak acid and its salt, which is a buffer.

D is not true. An acid solution would have a lower pH than a salt solution.

Ans: C

14 The graph shows the change in pH when 0.10 mol dm^{-3} acid is gradually added to 10 cm^3 of 0.1 mol dm^{-3} sodium hydroxide.



Which of the following correctly identifies the acid used and the point on the curve at which maximum buffer capacity occurs?

	Acid used	Maximum buffer capacity
A	HCN	**I**
B	H_2SO_4	**H**
C	HF	**J**
D	$(COOH)_2$	**I**

The quantities of acid and base used indicate that the ratio of acid: base is 1:1, so that rules out B and D. The maximum buffer capacity is formed when [salt]=[weak acid/base], which occurs only at point J.

Ans: C

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

An electrochemical cell is set up using a $Fe^{3+}(aq)$, $Fe^{2+}(aq)$ half–cell and a $VO^{2+}(aq)$, $V^{3+}(aq)$ half–cell.

Which of the following gives a correct effect on the $E^{\ominus}_{cell}$ when each of the changes is made?

	Change	Effect on $E^{\ominus}_{cell}$
A	Doubles the concentration of Fe^{3+}	$E^{\ominus}_{cell}$ doubles
B	Addition of KCN(aq) to the $Fe^{3+}(aq)$, $Fe^{2+}(aq)$ half–cell	$E^{\ominus}_{cell}$ becomes more positive
C	Addition of water to the $VO^{2+}(aq)$, $V^{3+}(aq)$ half–cell	$E^{\ominus}_{cell}$ becomes more positive
D	Addition of NaOH to the $VO^{2+}(aq)$, $V^{3+}(aq)$ half–cell	$E^{\ominus}_{cell}$ becomes less positive

$Fe^{3+} + e \leftrightarrow Fe^{2+}$ E = +0.77

$VO^{2+} + 2H^{+} + e \leftrightarrow V^{3+} + H_2O$ E = +0.34

For A, doubling the concentration of Fe^{3+} results in the eq of the Fe^{3+}/Fe^{2+} half-cell shifting left, but not to the extent that E_{cell} is likely to double.

For B, adding KCN results in the formation of $[Fe(CN)_6]^{3+}$ and $[Fe(CN)_6]^{2+}$, which reduces the E to +0.36. The E_{cell} becomes less positive.

$[Fe(CN)_6]^{3+} + e \leftrightarrow [Fe(CN)_6]^{2+}$ E = +0.36

For C, adding water decreases the concentration of ions in the solution. To counter this decrease, the system tries to increase the concentration of ions by shifting the eq of the VO^{2+}/V^{3+} half-cell to the left, resulting in a less positive E value, which leads to a more positive E_{cell}.

For D, adding NaOH results in a decrease in H^{+}, so the equilibrium for the VO^{2+}/V^{3+} half-cell shifts to the left, resulting in a less positive E value, which leads to a more positive E_{cell}.

Ans: C

16 Two separate electrolyses were performed as follows, under standard conditions.

1) When concentrated hydrochloric acid was electrolysed for 10 minutes, 150 cm^3 of gas were collected from the anode.
2) When aqueous copper sulfate was electrolysed for 10 minutes, **x** cm^3 of gas were collected from the anode.

If the current used in electrolysis 1 was twice the current used in electrolysis 2, what is the volume of gas that were collected in electrolysis 2?

A 37.5 cm^3

B 50 cm^3

C 75 cm^3

D 125 cm^3

$2Cl^- \rightarrow Cl_2 + 2e$

Let the amt of Cl_2 collected be 150/24 = 6.25 mol. Therefore, the amt of electrons transferred would be 6.25 x 2 = 12.5 mol.

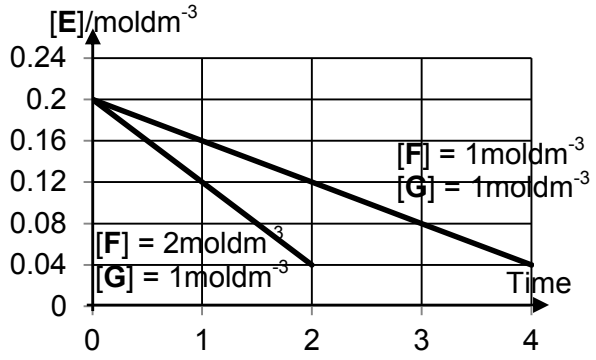
For reaction 2, the gas collected is O_2 gas from $2H_2O \rightarrow O_2 + 4H^+ + 4e$

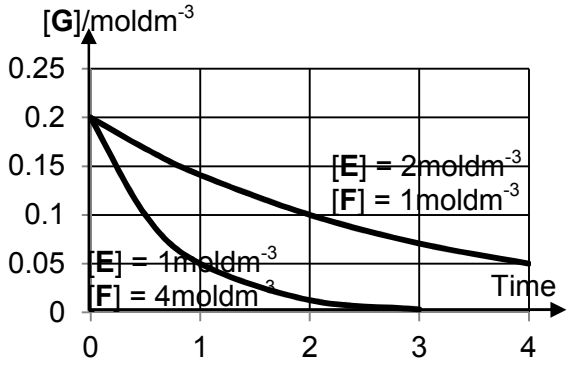
But current used is twice that in reaction 1, so amt of electrons transferred is now 12.5/2 = 6.25 mol. Therefore, amt of O_2 produced = 6.25/4 = 1.5625 mol → 37.5 cm^3

Ans: A

17 **E, F** and **G** react according to the following equation: **E**(aq) + 2**F**(aq) + **G**(aq) ⟶ products

Two sets of separate experiments are performed in order to determine the rate equation. The results are shown:





Which of the following statements is **not** true?

A For this reaction, the rate equation is based on the overall equation.

B The order of reaction with respect to [**E**] is zero.

C The order of reaction with respect to [**F**] is one.

D The order of reaction with respect to [**G**] is one.

Deduce the rate equation:
For 1st graph, the lines shown are straight lines, so [E] has no effect on the rate, so order of rxn wrt E is zero.
Comparing the gradients of the two lines in the 1st graph, it shows that the rate doubled when [F] doubled, so the order of rxn wrt F is one.
For the 2nd graph, one of the lines shows that there is a constant half-life for [G], which is 2 time units when 0.2 → 0.1 and 0.1 → 0.05, so order of rxn wrt G is one.
Ans: A

18 Which of the following statements about the Period 3 elements is true across the period?

A The melting points of the elements decrease steadily.

B The electrical conductivity of the elements decreases steadily.

C The pH of the oxides in water decreases steadily.

D The solubility of the oxides in water increases steadily.

A is not true. From Na to Si, mp increases.

B is not true. From Na to Al, electrical conductivity increases.

C is true as the oxides change from basic to amphoteric to acidic.

D is not true as SiO_2 is not soluble – there is no clear trend.

Ans: C

19 In which of the following reactions is chlorine gas formed?

A NaC*l* is heated strongly with iodine.

B NaC*l* is heated with concentrated sulfuric acid.

C HC*l* is heated with concentrated sulfuric acid and manganese (IV) oxide.

D KC*l* is heated with aqueous iron (III) sulfate.

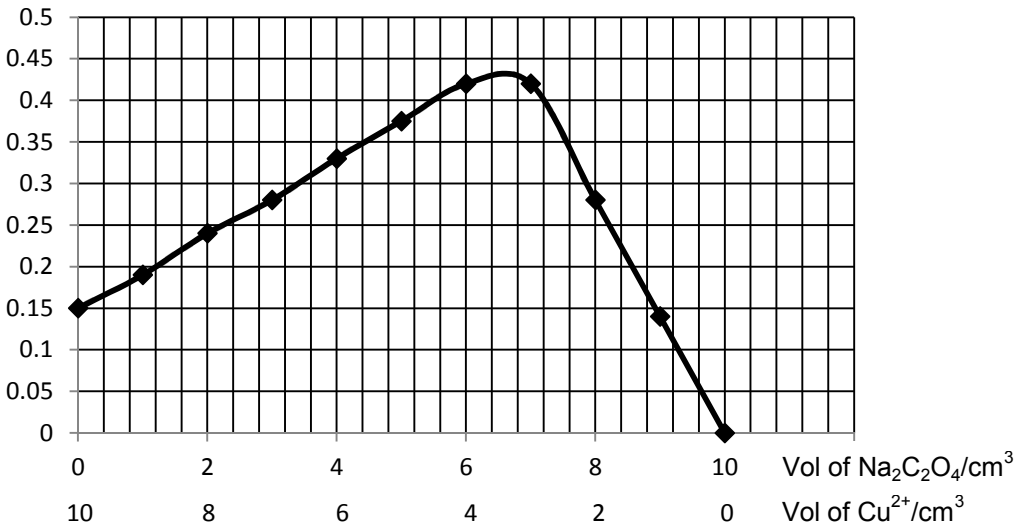
A and B are not possible as Cl^- has low reducing power.

D is not possible as Fe^{3+} is not strong enough to oxidise Cl^-.

C is possible as MnO_2 behaves as a catalyst for the reaction. (also by process of elimination)

Ans: C

20 The stoichiometry of a complex can be determined by measuring the colour intensities of solutions containing different proportions of the ligand and metal ion. The following graph was obtained when different amounts of 1.0×10^{-4} mol dm^{-3} $Cu^{2+}(aq)$ and 1.0×10^{-4} mol dm^{-3} sodium ethanedioate solution were mixed.



Which of the following is the correct formula for the complex?

A $[Cu_2(C_2O_4)_3]^{2-}$ **B** $[Cu_3(C_2O_4)_2]^{2+}$

C $[Cu(C_2O_4)_3]^{4-}$ **D** $[Cu(C_2O_4)_2]^{2-}$

Reading from the graph, the vol of $C_2O_4^{2-}$ added is 6.6 cm^3, while that of Cu^{2+} is 3.4 cm^3. Since they have the same concentration, it means that the maximum absorbance is obtained when their molar ratios are in the ratio 6.6:3.4 → 1.94:1 ~ 2:1. Therefore answer is D.

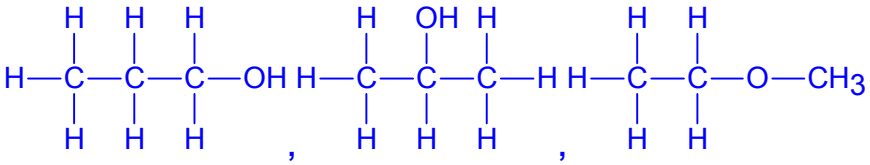
Ans: D

21 How many structural isomers are there for C_3H_8O?

A 1 **B** 2

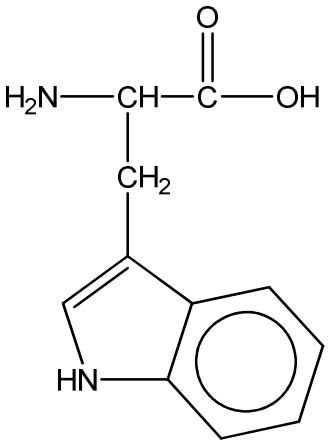
C 3 **D** 4

3 isomers



Ans: C

22 Tryptophan is an amino acid and is essential to the human diet. It also serves as a biological precursor to some chemicals associated with the nervous system of the human body. It has an isoelectric point of 5.89.



What of the following statements is **not** true about tryptophan?

A It undergoes an electrophilic substitution reaction with Br_2 (aq).

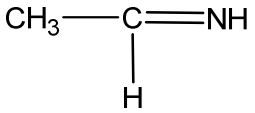
B It is chiral.

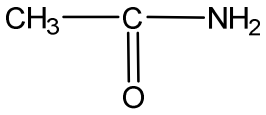
C It reacts with 3 moles of ethanoyl chloride.

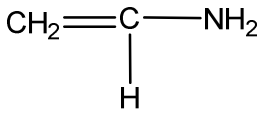
D It has a positive charge when placed in a solution at pH 3.

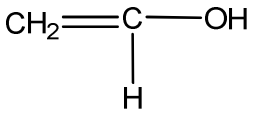
A is true – the presence of an alkene can react with Br_2(aq).
B is true – the carbon between the amine and carboxylic group is chiral.
C is not true – acid chloride will react only with the two amine groups, but not with the carboxylic acid.
D is true – both amine groups will be protonated in acidic solution.
Ans: C (LA)

23 1-chloroethylamine reacts with aqueous sodium hydroxide under heat. The product then undergoes a rapid dehydration to form **K**. **K** does not react with bromine in tetrachloromethane. What is the likely structure of **K**?

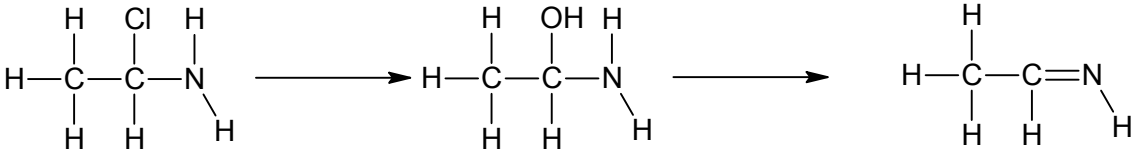
A


B


C


D


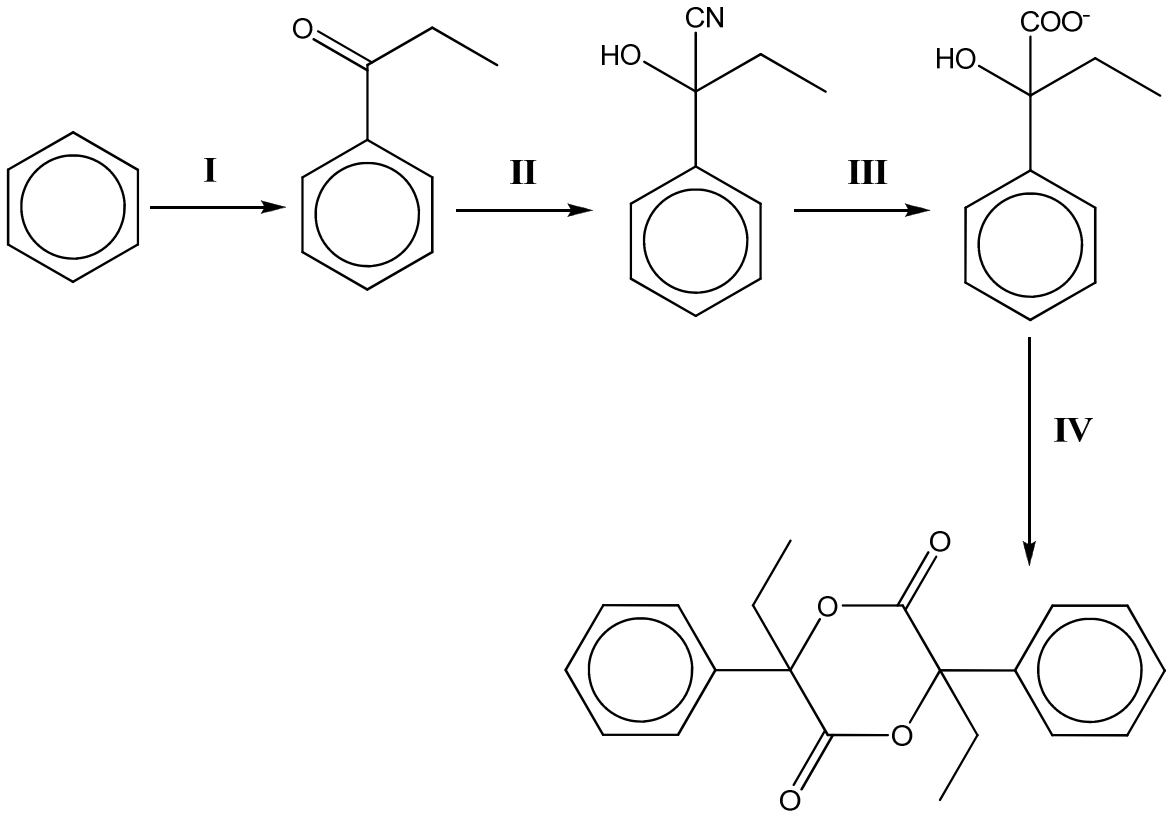
Nucelophilic substitution takes place first. Elimination then occurs to result in a double bond.



The answer cannot be B or D because oxygen is lost during the dehydration step. It also cannot be C because C can react with Br_2 in CCl_4.

Ans: A

24 For the following conversion sequence, which of the steps stated will not result in a good yield?



A Step **I** - Propanoyl chloride with aqueous iron (III) chloride

B Step **II** - Hydrogen cyanide with trace potassium cyanide at 15^0C

C Step **III** - Dilute aqueous sodium hydroxide with heat

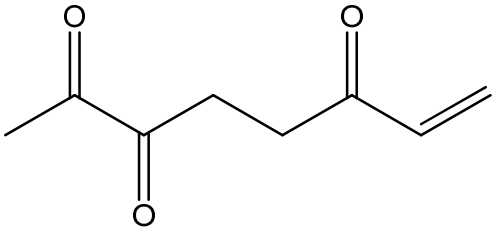
D Step **IV** - Concentrated sulfuric acid with heat

A gives the worst yield due to the aqueous conditions for $FeCl_3$. All the other reaction steps are suitable and appropriate for their reactions.

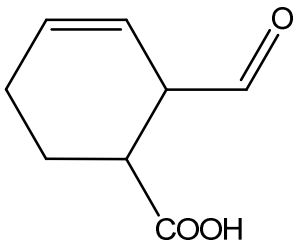
Ans: A

25 Compound **L** has the molecular formula $C_8H_{10}O_3$. It reacts with 2 moles of hydrogen gas in the presence of a platinum catalyst to form a compound with the formula $C_8H_{14}O_3$.
Which of the following could be **L**?

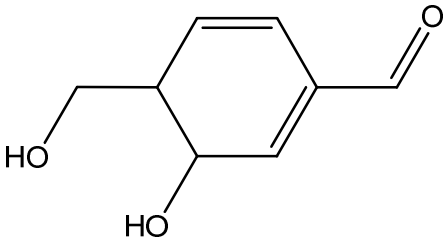
A



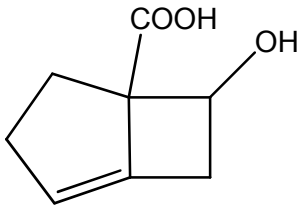
B



C



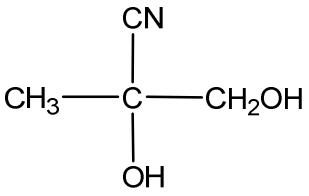
D



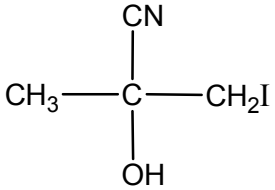
A has 4 functional groups that will be reduced by H_2.
B has 2 functional groups that will be reduced by H_2.
C has 3 functional groups that will be reduced by H_2.
D has 1 functional group that will be reduced by H_2.
Ans: B

26 Which of the following are **not** possible products when 1-iodopropanone reacts with an equimolar mixture of hydrogen cyanide and sodium hydroxide in ethanol?

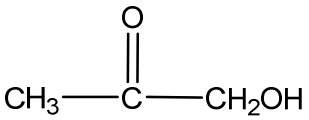
A



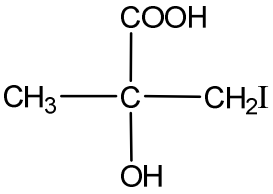
B

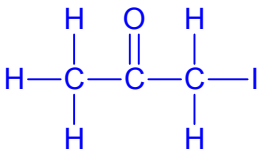


C



D

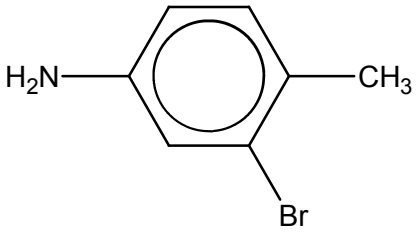




- 1 iodopropanone

Nucleophilic substitution can occur with CN^- substituting the iodine.
Elimination can also occur with the I and a neighboring H removed by the action of NaOH.
Presence of NaOH and HCN can also result in nucleophilic addition.
A is possible – nucleophilic addition and nucleophilic sub
B is possible – nucleophilic addition only
C is possible – nucleophilic substitution only
D is not possible – basic hydrolysis would be involved and the product would be a carboxylate ion group instead.
Ans: D

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



A Nitration, bromination, alkylation, reduction

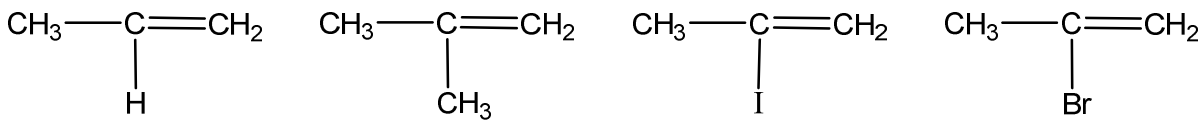
B Nitration, bromination, reduction, alkylation

C Nitration, alkylation, reduction, bromination

D Alkylation, bromination, nitration, reduction

Option A results in a contest between the NO_2 and Br groups to determine the position of the CH_3 group.
Option B will result in the best yield because the NH_2 and Br groups will reinforce each other's activating effects on the CH_3.
Option C results in a contest between the NO_2 and CH_3 groups to determine the position of the Br group.
Option D results in a contest between the Br and CH_3 groups to determine the position of the NO_2 group.
Ans: B

28 A comparison is made of the rate of electrophilic addition of Br_2 in CCl_4 to the following compounds:



O **P** **Q** **R**

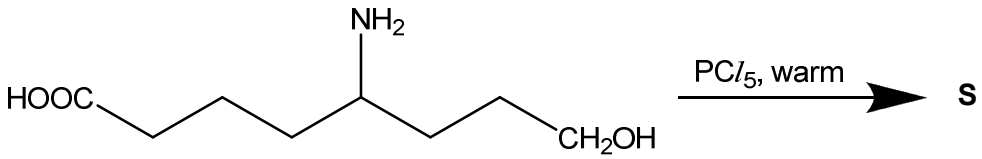
How will the reaction rates for each compound vary?

	Fastest → Slowest			
A	**P**	**O**	**Q**	**R**
B	**Q**	**R**	**O**	**P**
C	**P**	**O**	**R**	**Q**
D	**O**	**P**	**R**	**Q**

The rate of electrophilic addition will depend on the electron density around the double bond. On this basis, P will have the fastest rate as the CH_3 group is electron donating and adds to the electron density of the double bond. R will have the slowest rate as Br is more electron withdrawing than I and results in a less electron rich double bond.

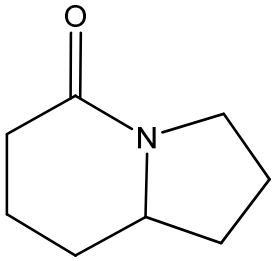
Ans: A

29 In the following reaction, one of the products is a solid compound **S**, which is insoluble in water.

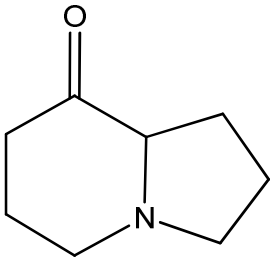


What is **S**?

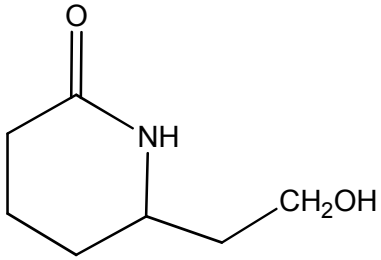
A



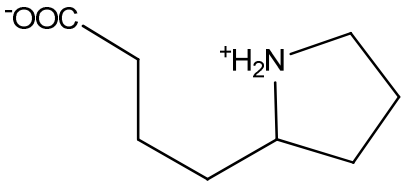
B



C



D



The fact that the product is insoluble in water rules out C and D. And since the presence of PCl_5 results in the formation of an acid chloride and an alkyl halide group, both of which can react with the amine, the final product is an amide. (Note: modeled after qn 27 of 2011 A level Paper 1)

Ans: A

30 Century eggs are a traditional Chinese food product. They are made by coating eggs in a mixture of clay, salt (NaC*l*), and quicklime (CaO). This curing process usually takes about a month.

Through the curing process, the yolk becomes a dark green colour, while the egg white becomes a dark brown, translucent jelly.

Which of the following is true about the curing process?

A The presence of salt disrupts the van der Waals' forces in the egg protein.

B Mechanical agitation disrupts the hydrogen bonds in the egg protein.

C The increase in pH disrupts the ionic interactions in the egg protein.

D Quicklime reduces the disulfide bridges in the egg protein.

A - Salt does not disrupt van der Waals' forces.
B – There is no mechanical agitation present.
C – Quicklime is a basic oxide and will increase the pH of a system.
D – quicklime does not engage in redox reactions.
Ans: C

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct. Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 1 dm^3 of gas $\mathbf{X_2}$ and 1 dm^3 gas $\mathbf{Y_2}$ weighs 2 g and 6 g respectively under the same conditions of temperature and pressure.
Which of the following statements are correct?

1 The average velocity of the molecules in gas **X** is higher than that of gas **Y** at the same temperature.

2 The ratio of the M_r of **X** to **Y** is 3:1.

3 $\mathbf{Y_2}$ behaves more ideally than $\mathbf{X_2}$ under the same conditions of temperature and pressure.

Can obtain by process of elimination. Statement 2 is not true – it should be X:Y is 1:3. Statement 3 is not true as X_2 has less mass and is therefore more likely to be ideal. Therefore statement 1 must be correct (total energy is the same, but since $E=1/2mv^2$,

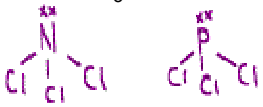
and mass of X is smaller than Y, X should have higher velocities to result in the same overall energy)

Ans: D (1 only)

32 In which pairs of species are the bond angle in **I** bigger than that in **II**?

	I	**II**
1	NCl_3	PCl_3
2	ICl_2^-	I_3^-
3	NO_3^-	NO_2^+

1

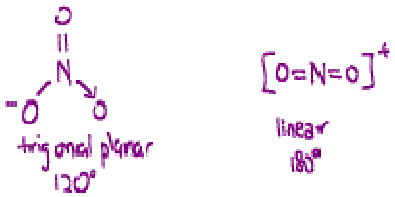


NCl_3 and PCl_3 are both trigonal pyramidal in shape. N in NCl_3 is more electronegative than P in PCl_3, bonding electrons are attracted more to the central atom N and hence bond pairs experience larger electronic repulsion resulting in larger bond angle in NCl_3.

2

ICl_2^- and I_3^- are both linear in shape. Therefore there is no difference in bond angle.

3



Ans: D (1 only)

33 The solubilities of Group II metal sulfates decrease down the group. Which of the following explanations are correct?

1 The hydration energy of the cations becomes less exothermic down the group.

2 The variation in lattice energy is larger than the enthalpy change of hydration down the group.

3 The sulfate ion can be easily polarised.

$\Delta H_{sol} = \Delta H_{hyd} - \Delta H_{LE}$

1 **TRUE. The cationic radius increases down the group hence the hydration energy of the cations becomes less exothermic down the group, hence ΔH_{sol}**

becomes less negative and solubility decreases down the group.

2 **Due to the large size of the sulfate anion, the inter-ionic distance is largely controlled by the size of the anion. Changes in the size of the cation do not make as great a percentage difference to the inter-ionic distance, hence there is little difference between the lattice energies down the Group. The variation in lattice energy is smaller than the enthalpy change of hydration down the group.**

3 **Will not affect solubility.**

Ans: D (1 only)

34 For which equilibrium does the value of $K_c = K_p$?

1 $H_2(g) + I_2(g) \rightleftharpoons 2HI_2(g)$

2 $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$

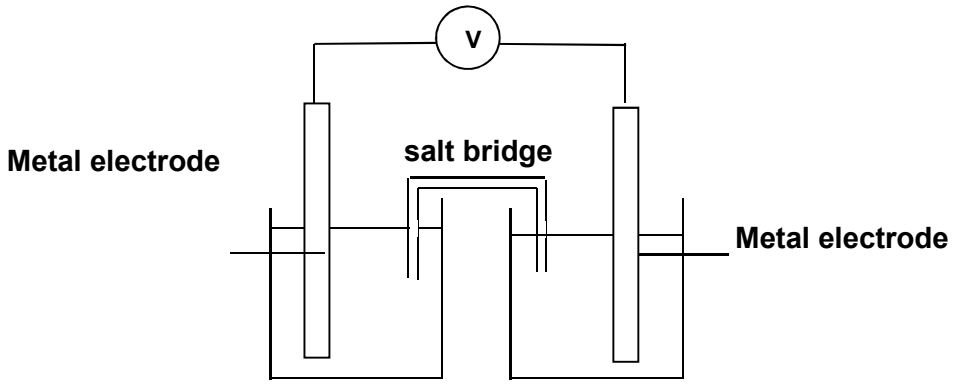
3 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

$K_c = K_p$ when the number of gaseous molecules is the same on both sides of the equation.

Therefore, only 1 is correct.

Ans: D (1 only)

35 Four metals **W**, **X**, **Y** and **Z**, were connected in pairs as shown in the diagram below and the voltage was recorded.



The results obtained are recorded in the table below.

Cell	Metals used	$E^{\ominus}_{cell}$ / V	Positive terminal
1	**W** and **X**	+1.10	**W**
2	**X** and **Y**	+1.46	**Y**
3	**X** and **Z**	+0.47	**X**

Which of the following statements are correct?

1 **Y** is the strongest oxidising agent.

2 $E^{\ominus}_{cell}$ for metals **W** and **Y** is +0.36 V

3 **W** can reduce all the cations of **Y**, **X** and **Z**.

Since this is electrochemical reaction, the positive terminal is the cathode where reduction occurs.

Cell 1 – W is a stronger oxidising agent than X, so it gets reduced.

Cell 2 – Y is a stronger oxidising agent than X, so it gets reduced.

Cell 3 – X is a stronger oxidising agent than Z, so it gets reduced.

Combining cell 1 and 2 – E_{cell} is higher for cell 2, so Y is a stronger oxidising agent than W. The order of oxidising power is thus Y > W > X > Z. Statement 1 is true, and statement 3 is not true (W can only reduce Y).

E_{cell} = E(W) – E(X) = +1.1, E_{cell} = E(Y) – E(X) = +1.46

E(W) = 1.1 + E(X), E(Y) = 1.46 + E(X)

For W and Y,

E_{cell} = E(Y) – E(W) = [1.46 + E(X)] – [1.1 + E(X)] = +0.36

Statement 2 is true.

Ans: B (1 and 2)

36 A yellow solution was formed when crystalline potassium chromate(VI) was dissolved in water. On addition of dilute sulfuric acid, the solution turned orange. Upon bubbling hydrogen sulfide through the orange solution, there was a colour change in the solution and yellow sulfur was formed.

Which of the following processes occur in the above experiment?

1 Ligand exchange

2 Redox reaction

3 Precipitation

Yellow solution : $CrO_4^{2-}(aq)$, Orange solution: $Cr_2O_7^{2-}(aq)$

Colour change upon bubbling hydrogen sulfide & yellow sulfur was formed (precipitation), so H_2S is oxidised while $Cr_2O_7^{2-}(aq)$ is reduced (redox)

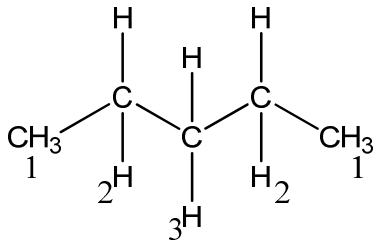
$3H_2S + 8H^+ + Cr_2O_7^{2-} \rightarrow 3S + 2Cr^{3+} + 7H_2O$

Ans: C (2 and 3)

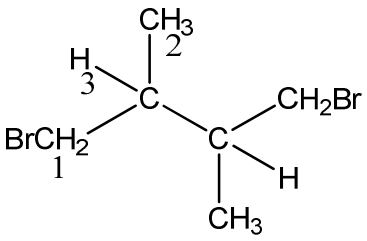
37 A compound **Z**, upon mono-chlorination with chlorine in the presence of UV light, forms 3 possible isomeric products.

Which of the following compounds could be **Z**?

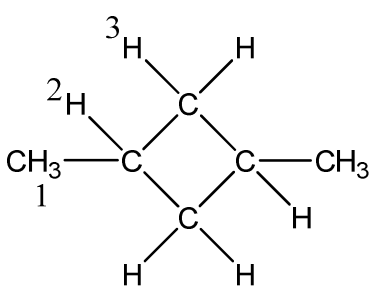
1



2

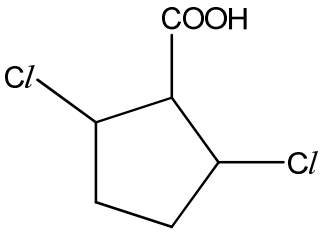


3



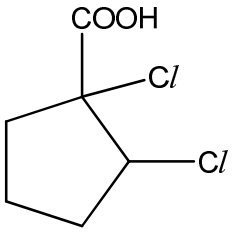
For 3 isomeric products to be formed, there can only be 3 types of hydrogen present in the compound. There are three types of hydrogen in each of the compounds.
Ans: A (1, 2, and 3)

38 Which of the following is more acidic than the compound below?



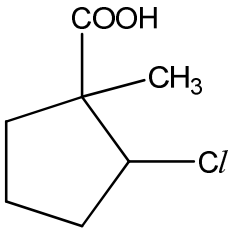
More acidic as the Cl is closer and has stronger electron withdrawing effect on the COOH group – stabilising the COO^- ion.

1



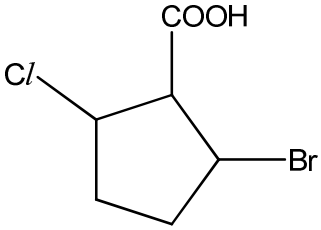
Less acidic as the CH_3 is an electron donating group – destabilises the COO^- ion.

2



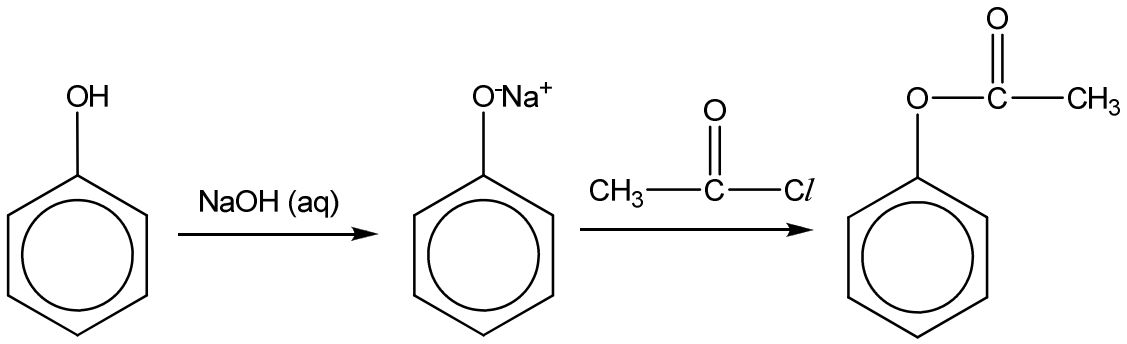
Less acidic as the Br is less electronegative and has a lesser electron withdrawing effect on the COOH group – the COO^- ion is not as stabilised.

3



Ans: D (1 only)

39 For the following sequence of reactions, which are valid reasons for the choice of reagents used?



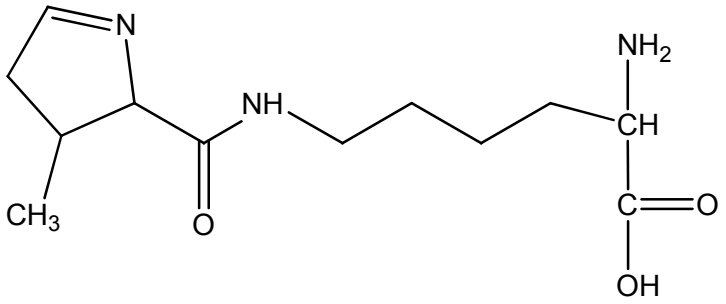
1 The formation of sodium phenoxide is necessary as it is soluble in water.

2 Phenoxide ion is a stronger nucleophile than phenol.

3 An acid chloride is used to improve the yield.

Statement 1 is true but not relevant as an acid chloride is used, which means that aqueous conditions are not used here.
Statement 2 is true and relevant as the formation of an ester here can be regarded as a nucleophilic substitution, with the phenoxide nucleophile replacing the Cl atom.
Statement 3 is true and relevant as an acid chloride is much more reactive and gives a higher yield.
Ans: C (2 and 3)

40 Pyrrolysine is a naturally occurring amino acid that appears in methane-producing bacteria.



Pyrrolysine

Which of the following statements are true of pyrrolysine?

1 It can be reduced by sodium borohydride.

2 It can form van der Waals interactions with proteins.

3 It undergoes condensation reaction with 2,4-dinitrophenylhydrazine.

Statement 1 is true as $NaBH_4$ can reduce C=N functional groups (not in syllabus, but can be inferred as statement 3 is definitely wrong and only option B is possible)
Statement 2 is true as the pyrrolysine has several alkyl groups/chains which can form van der Waals interactions.
Statement 3 is not true as no carbonyl group is present.
Ans: B (1 and 2)