

CHEMISTRY

Paper 1 Multiple Choice

8872/01

WEDNESDAY 2 SEPTEMBER 2015

50 minutes

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 and/or shade your name, NRIC / FIN number and HT group on the Multiple Choice Answer Sheet provided.

There are **thirty MCQ** questions in 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.

ANSWERS

Section A

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

- 1 The element zinc has four stable isotopes.

isotope	Relative abundance / %
^{64}Zn	49.29
^{66}Zn	27.83
^{67}Zn	4.14
^{68}Zn	18.74

Use the relative abundance data to find the relative atomic mass of zinc to 2 decimal places.

A 65.40

B 65.42

C 65.43

D 65.45

$$\begin{aligned}
 A_r &= \left(\frac{49.29}{100} \times 64 \right) + \left(\frac{27.83}{100} \times 66 \right) + \left(\frac{4.14}{100} \times 67 \right) + \left(\frac{18.74}{100} \times 68 \right) \\
 &= 65.4304 \\
 &= 65.43 \text{ (2dp)}
 \end{aligned}$$

Answer: C

- 2 A liquid organic acid that contains sulfur has the formula $C_xH_yS_zO$. The liquid was completely burnt in 50 cm^3 of oxygen gas in an enclosed vessel. At the end of the reaction, there was a 5 cm^3 reduction in the total volume of gas present.

The carbon dioxide produced occupied twice the volume of the sulfur dioxide produced.

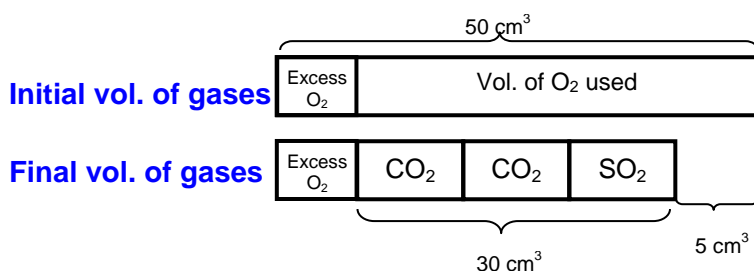
When the mixture of gases was passed through aqueous sodium hydroxide, the volume was reduced by 30 cm^3 . Given that all measurements of gases were at room temperature and pressure, what is the possible formula of the organic acid?

A C_2H_4SO

B $C_2H_4S_2O$

C $C_4H_6S_2O$

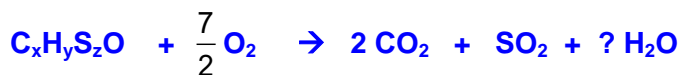
D $C_4H_4S_2O$



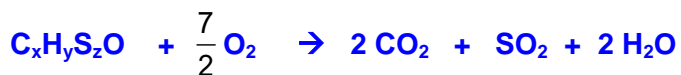
Total volume of oxygen used in the combustion = $30 + 5 = 35\text{ cm}^3$

Unbalanced: gaseous volume reacted / formed / cm^3	$C_xH_yS_zO$ NA	+	O_2 35	→	CO_2 20	+	SO_2 10	+	H_2O -
Ratio	1		3.5 (or $\frac{7}{2}$)		2		1		-

Hence, the partially balanced equation is:



LHS: 8 oxygen atoms. Hence, RHS should be $2H_2O$.



By inspection, $x = 2$, $y = 4$ and $z = 1$

Answer: A

- 3 What are the number of moles of Cr^{3+} and SO_4^{2-} contained in 0.5 dm^3 of 0.2 mol dm^{-3} hydrated chromium(III) sulfate, $\text{Cr}_2(\text{SO}_4)_3 \cdot 12\text{H}_2\text{O}$?

	Cr^{3+}	SO_4^{2-}
A	0.1	0.15
B	0.2	0.3
C	0.3	0.2
D	0.4	0.6

Amount of $\text{Cr}_2(\text{SO}_4)_3 \cdot 12\text{H}_2\text{O} = 0.5 \times 0.2 = 0.100 \text{ mol}$

Amount of $\text{Cr}^{3+} = 2 \times 0.100 \text{ mol} = 0.200$

Amount of $\text{SO}_4^{2-} = 3 \times 0.100 \text{ mol} = 0.300$

Answer: B

- 4 Which ion is least deflected in an electric field?

A $^{32}\text{S}^{2-}$	B $^{39}\text{K}^{+}$	C $^{24}\text{Mg}^{2+}$	D $^{31}\text{P}^{3-}$
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angle of deflection $\propto \frac{|\text{charge}|}{|\text{mass}|}$ of particle

A $\frac{|\text{charge}|}{|\text{mass}|} = 2/32 = 0.0625$

B $\frac{|\text{charge}|}{|\text{mass}|} = 1/39 = 0.0256$

C $\frac{|\text{charge}|}{|\text{mass}|} = 2/24.3 = 0.0833$

D $\frac{|\text{charge}|}{|\text{mass}|} = 3/31 = 0.0968$

Answer: B

- 5 Use of the Data Booklet is relevant to this question.

Archaeologists used ^{14}C , a radioactive isotope, in carbon dating. Which particle has the same number of neutrons and the same number of electrons as an atom of ^{14}C ?

A $^{14}\text{N}^{+}$	B $^{16}\text{O}^{2+}$	C $^{17}\text{F}^{+}$	D ^{28}Si
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		A	B	C	D
	^{14}C	$^{14}\text{N}^{+}$	$^{16}\text{O}^{2+}$	$^{17}\text{F}^{+}$	^{28}Si
No. of n	8	7	8	8	14
No. of e	6	6	6	8	14

Answer: B

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

Which of the following has an unpaired electron in a spherically-shaped orbital?

- A Na^+ B Al C Sc **D Cr**

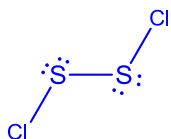
Spherically shaped orbital: s orbital

- A Na^+ : $1s^2 2s^2 2p^6$
 B Al : $1s^2 2s^2 2p^6 3s^2 3p^1$
 C Sc : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$
 D Cr : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

Answer: D

- 7 Disulfur dichloride has the formula S_2Cl_2 . What is the likely bond angle at each sulfur atom in the molecule?

- A 107°** B 109° C 120° D 180°

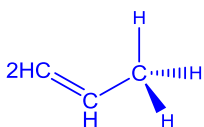


Around each S: 2 lp and 2 bp. Basic shape is tetrahedral (109°) but due to the lone pairs, the bond angle needs to be smaller than 109° , hence the best answer is 107° .

Answer: A

- 8 Which of the following molecules is planar?

- A C_3H_6 B C_7H_8 C Al_2Cl_6 **D $\text{C}_6\text{H}_5\text{Cl}$**



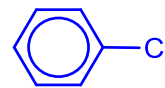
A



B



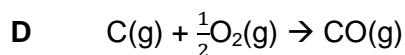
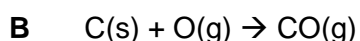
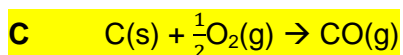
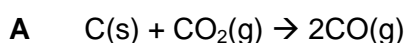
C



D

Answer: D

9 Which equation correctly defines the enthalpy change of formation of carbon monoxide?



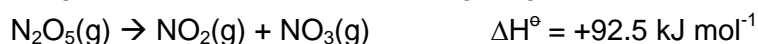
Enthalpy change of formation: to form one mole of CO(g) (Option **A** is incorrect) from its constituent elements in standard state. (Option **B** incorrect because oxygen is not in its diatomic form and option **D** is incorrect because carbon is not a gas at standard conditions.)

Answer: C

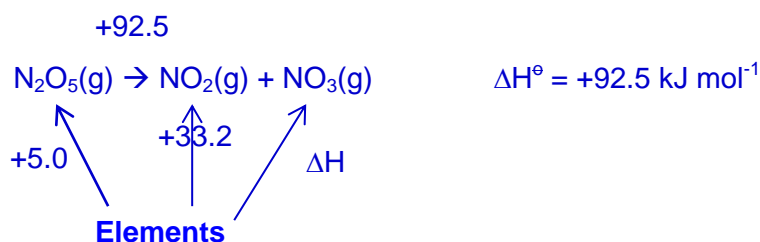
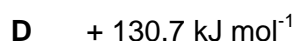
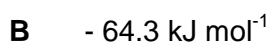
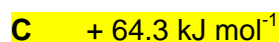
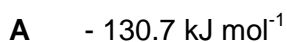
10 The following table lists some ΔH_f^\ominus values.

Compound	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{NO}_2(\text{g})$	+33.2
$\text{N}_2\text{O}_5(\text{g})$	+5.0

The enthalpy change for the dissociation of $\text{N}_2\text{O}_5(\text{g})$ is given below.



What is the standard enthalpy change of formation of $\text{NO}_3(\text{g})$?

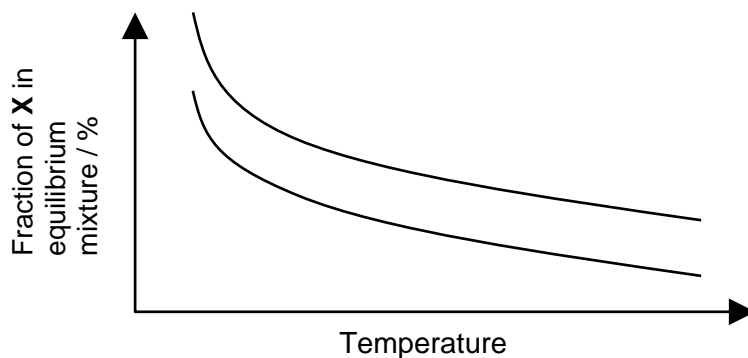
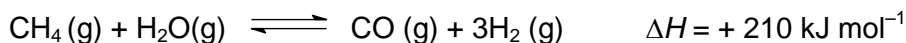


Using Hess' Law, $+5.0 + 92.5 = +33.2 + \Delta H$

$\Delta H = +64.3 \text{ kJ mol}^{-1}$

Answer: C

- 11 The graph below shows how the fraction of a substance, **X**, represented by one of the following compounds in the equilibrium mixture shown below, varies with temperature at pressures of m Pa and n Pa.



Identify **X** and the correct relative magnitudes of m and n .

	X	Pressure
A	CH₄	$m > n$
B	H ₂	$m > n$
C	CO	$n > m$
D	H ₂ O	$n > m$

As temperature increases, the fraction of **X** in the equilibrium mixture drops. The increasing temperature should cause the endothermic reaction to be favored. Since the enthalpy change of reaction is positive, this means that the forward reaction is favored, and more products are formed, while less reactants remain in the mixture. Thus, **X** must be a reactant (**CH₄ or H₂O**).

There are more gaseous molecules of products than reactants. From m Pa to n Pa, there are less **X** produced. This suggests that less reactant remains when the pressure is changed from m Pa to n Pa. This means that more products are formed and the forward reaction is favored, from m Pa to n Pa. Thus n Pa must be a lower pressure than m Pa, i.e. **$m > n$**

Answer: A

- 12 The Haber Process is the commercial method used to manufacture ammonia. Which of the following is true of this process?



- A A low temperature of 200°C is used so that the forward exothermic reaction is favoured.
- B Finely divided iron catalyst is used to increase the speed and to increase the yield of ammonia.
- C A high temperature of 450°C ensures a good speed of reaction and that the forward reaction is favoured.
- D A pressure of about 200 atm is high enough to give a good yield of ammonia as the equilibrium shifts to the right.

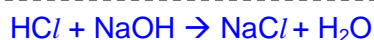
- A Incorrect. Temperature is 450 to 500°C .
- B Incorrect. Catalyst does not increase the yield.
- C A high temperature of 450°C favours the backward endothermic reaction.

Answer: D

- 13 A solution was made by mixing 0.0800 mol of $\text{HCl}(\text{aq})$ and 0.0500 mol of $\text{NaOH}(\text{aq})$. Water was added until the total volume of the solution was 1.5 dm^3 .

What is the pH of the solution?

- A 1.5 B 1.3 C 1.7 D 7.0



Amount of HCl needed = 0.05 mol

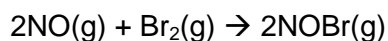
Amount of HCl in excess in $1.5 \text{ dm}^3 = 0.08 - 0.05 \text{ mol} = 0.03 \text{ mol}$

Since $[\text{H}^+] = [\text{HCl}]$, $[\text{H}^+] = 0.03/1.5 = 0.02 \text{ mol dm}^{-3}$.

$\text{pH} = -\lg[\text{H}^+] = -\lg(0.02) = 1.7$

Answer: C

- 14 The kinetics of the reaction



are second order with respect to $[\text{NO}]$ and first order with respect to $[\text{Br}_2]$. What are the units of the rate constant?

- A $\text{mol dm}^{-3} \text{s}^{-1}$ C $\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$
 B $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$ D $\text{mol}^{-3} \text{dm}^9 \text{s}^{-1}$

$$\text{Rate} = k[\text{NO}]^2[\text{Br}_2]$$

Units of LHS: $\text{mol dm}^{-3} \text{s}^{-1}$

Units on RHS: (units of k)(mol dm^{-3})²(mol dm^{-3})

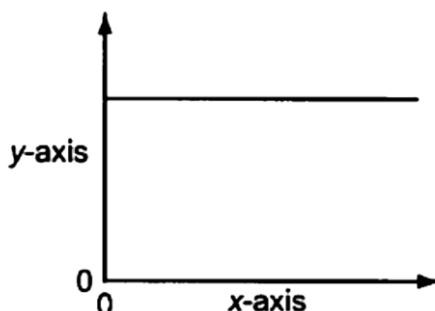
$$\text{mol dm}^{-3} \text{s}^{-1} = (\text{units of } k)(\text{mol dm}^{-3})^2(\text{mol dm}^{-3})$$

$$(\text{mol dm}^{-3})^{-2} \text{s}^{-1} = (\text{units of } k)$$

$$\text{mol}^{-2} \text{dm}^6 \text{s}^{-1} = (\text{units of } k)$$

Answer: C

- 15 The reaction $\text{A} \rightarrow \text{B}$ was found to be a zero order reaction. What would be the x and y axes that would give rise to the following graph?



	y-axis	x-axis
A	rate	concentration
B	concentration	rate
C	concentration	time
D	time	concentration

Zero order reaction means that the rate of the reaction is independent of the concentration of the reactant A. So, even when concentration changes (x-axis), the rate is constant (y-axis).

Answer: A

- 16 A particular reaction $B \rightarrow C + D$ is first order with respect to $[B]$. The numerical value of the rate constant is $5.78 \times 10^{-3} \text{ s}^{-1}$. Approximately how many half-lives have passed after a period of 10 minutes?
- A 3 **B 5** C 7 D 10

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{5.78 \times 10^{-3}} = 120 \text{ seconds} = 2 \text{ min}$$

$$\text{no. of half-lives} = \frac{10 \text{ min}}{2 \text{ min}} = 5$$

Answer: B

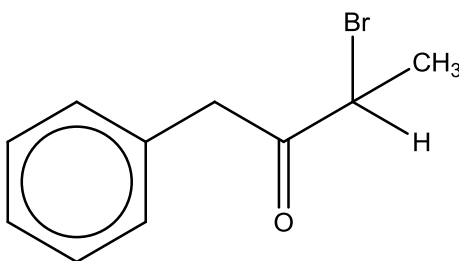
- 17 Which of the following elements will form a chloride that will **not** undergo hydrolysis upon reaction with water?

A Na B Mg C Si D P

NaCl is neutral and it will dissolve in water without hydrolysis to form a neutral solution.

Answer: A

- 18 What are the functional groups present in the molecule shown below?



- A phenyl, aldehyde and tertiary alkyl bromide
 B phenyl, aldehyde and secondary alkyl bromide
 C phenyl, ketone and tertiary alkyl bromide
D phenyl, ketone and secondary alkyl bromide

Knowledge of the phenyl group is irrelevant in this example.

The ketone group is obvious, as the aldehyde group requires a $-\text{CHO}$ configuration. There may be a tendency to ignore the H and identify the functional group as a tertiary alkyl bromide, instead of secondary (with two alkyl groups only).

Answer: D

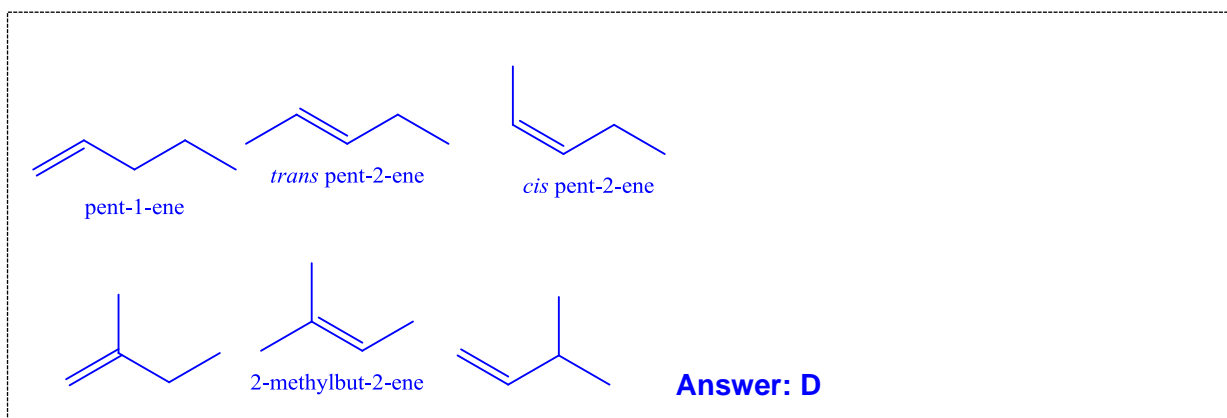
- 19 How many structural and geometric isomers are there in a compound with a molecular formula C_5H_{10} , **excluding** all cyclic structures?

A 3

B 4

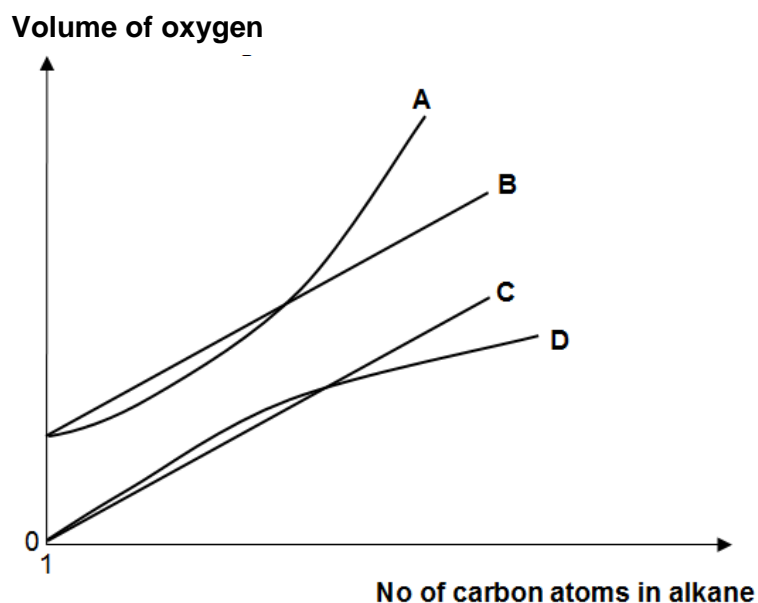
C 5

D 6



- 20 Alkanes undergo complete combustion in the presence of excess of oxygen to form only carbon dioxide and water at room temperature and pressure.

Which of the following graphs shows the relationship between the number of carbon atoms in an alkane and the volume of oxygen gas needed for complete combustion of one mole of the alkane?



Using the equation for complete combustion of alkane,

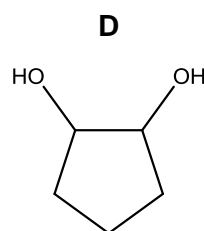
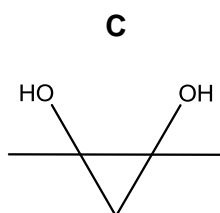
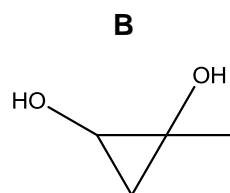
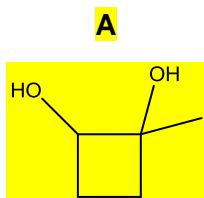


from this equation, it can be seen that when carbon no. increases by 1, there is an proportional increase of $(3x+1)/2$ in the no. of moles of O_2 required. The graph should show a constant gradient, ie, a straight line.

The smallest member of the alkane homologous series has 1 carbon, therefore, the no. of moles of O_2 required can never be 0.

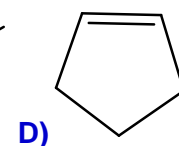
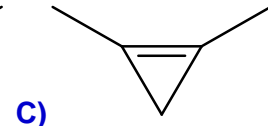
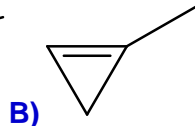
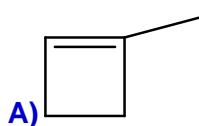
Answer: B

- 21 Hydrocarbon **X**, produces $\text{HO}_2\text{CCH}_2\text{CH}_2\text{COCH}_3$ upon heating with an excess of hot concentrated acidified $\text{KMnO}_4(\text{aq})$. Which of the following is the product of a mild oxidation of **X** with dilute cold alkaline $\text{KMnO}_4(\text{aq})$?



Upon oxidation, **X** must contain five carbon atoms but option **B** only has four carbon atoms.

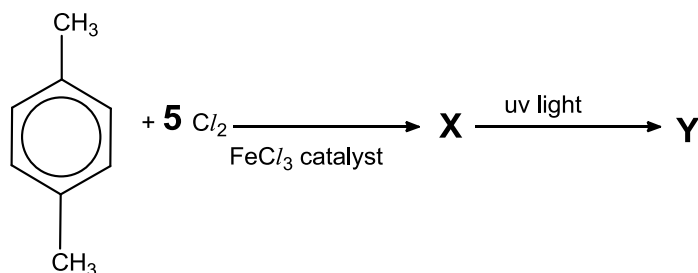
Secondly, by deriving the reactant alkenes from the diols given above, these are obtained:



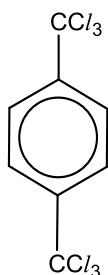
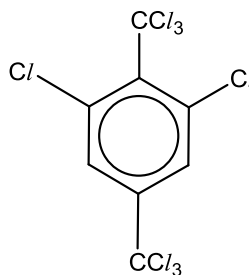
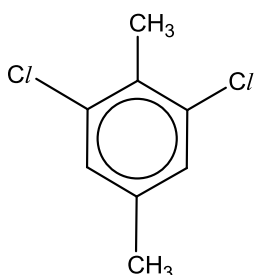
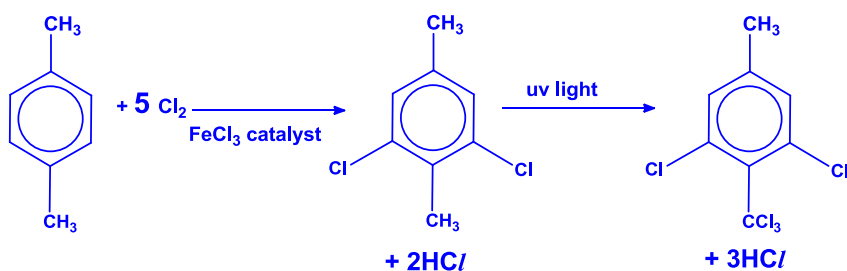
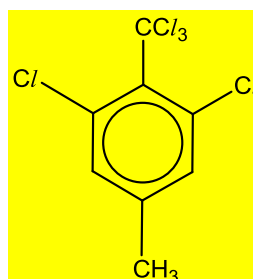
After the initial strong oxidative cleavage, option A would give both $-\text{COOH}$ and ketone functional groups. Option B has already been eliminated. Option C would give two ketone functional groups (incorrect), while option D would give two COOH groups.

Answer: **A**

- 22 Arenes are able to undergo substitution reactions with chlorine under different conditions. One such reaction, with the exact stoichiometric ratio given, is as follows:



Which of the following is the most likely product, **Y**, from this synthesis?

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

Firstly, options A and C can be quickly eliminated because they are incomplete products as the substitution did not occur on both the ring and the alkyl group. Secondly, option B is incorrect because it has substituted a total of 8 Cl atoms into the original molecule. For substitution reactions with Cl_2 , there is always a HCl by-product formed. As such, only 5 Cl atoms in total are available for substitution.

Answer: D

- 23 Chlorofluorocarbons, CFCs, are widely used but can cause damage to the ozone layer when the weakest bond in CFCs break to give free radicals that catalyse the breaking down of the ozone layer.

A typical chlorofluorocarbon is CH_2FCHClF .

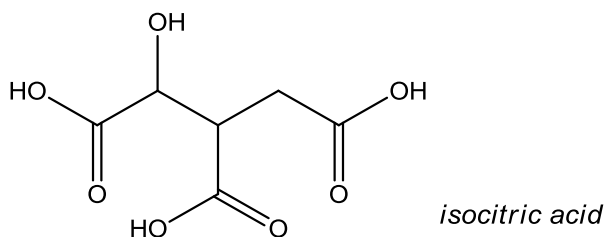
Which is the weakest covalent bond in this CFC?

- A C-H B C-F C C-C **D C-Cl**

Answer: D

The C-Cl bond involves a period 2 element (carbon) bonded to a period 3 element (chlorine). All other options involve the bonding between two period 2 elements. Hence the C-Cl bond is expected to be longer and weaker than the rest. This question is similar to the 2009 MCQ.

- 24 Isocitric acid, shown below, is an isomer of citric acid, which is commonly found in citrus fruits like the grapefruit.



Which of the following reagents react completely with 1 mol of isocitric acid?

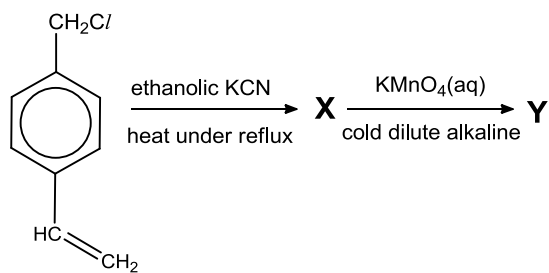
- A 2 mol of $\text{CH}_3\text{CH}_2\text{OH}$
 B 3 mol of Na_2CO_3
C 4 mol of Na
 D 4 mol of NaOH

There are 3 $-\text{CO}_2\text{H}$ group and 1 $-\text{OH}$ group.

- A For every mol of $\text{CH}_3\text{CH}_2\text{OH}$, 1 mol of $-\text{COOH}$ group (acid for esterification) will react. Since there are 3 $-\text{COOH}$ group, 3 mol of $\text{CH}_3\text{CH}_2\text{OH}$ is required. **False**
 B For every mol of Na_2CO_3 , 2 mol of $-\text{CO}_2\text{H}$ group will react. Hence, 1.5 mol of Na_2CO_3 is required. **False**
 C For every mol of Na, 1 mol of $-\text{CO}_2\text{H}$ group or 1 mol of $-\text{OH}$ group will react. Since there is 3 $-\text{CO}_2\text{H}$ group and 1 $-\text{OH}$ group, 4 mol of Na is required.
 D For every mol of NaOH, 1 mol of $-\text{CO}_2\text{H}$ group will react. Since there is 3 $-\text{CO}_2\text{H}$ group, 3 mol of NaOH is required. Alcohols do not react with NaOH. **False**

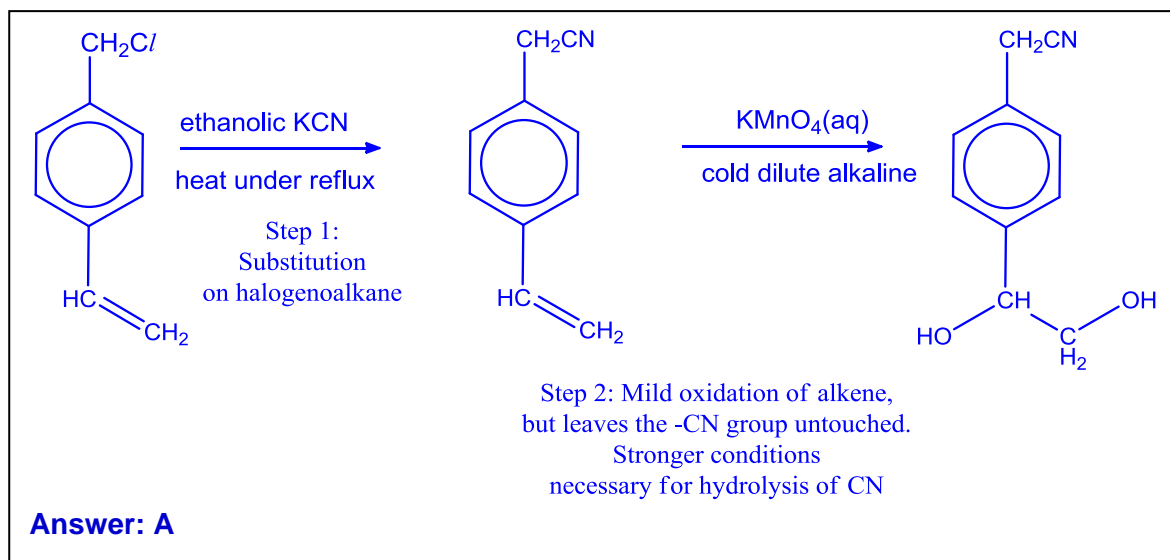
Answer: C

25 A synthesis reaction was carried out as follows:



Which organic products are formed from this synthesis?

- A**
- | | |
|--------------|--------------|
| X
 | Y
 |
|--------------|--------------|
- B**
- | | |
|--|--|
| | |
|--|--|
- C**
- | | |
|--|--|
| | |
|--|--|
- D**
- | | |
|--|--|
| | |
|--|--|



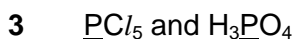
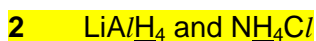
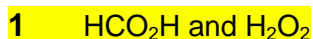
Section B

For each of 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. Decide whether each of the statements is or is not 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 combinations of statements are used as a correct response.

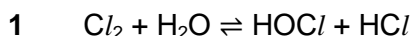
26 In which pairs of compounds do the underlined elements exhibit different oxidation states?



- 1 oxygen is -2 in HCO_2H but -1 in H_2O_2
 2 hydrogen is -1 in LiAlH_4 but +1 in NH_4Cl
 3 phosphorus is +5 in both PCl_5 and H_3PO_4

Answer: B

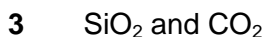
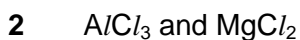
27 In which of the following reactions do two conjugate acid-base pairs exist?



- 1 This is a redox reaction and not an acid-base reaction.
 2 The pairs are $\text{ClO}^- / \text{HClO}$ and $\text{H}_2\text{O} / \text{OH}^-$
 3 The pairs are $\text{HSO}_4^- / \text{SO}_4^{2-}$ and CN^- / HCN

Answer: C

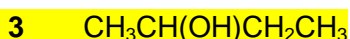
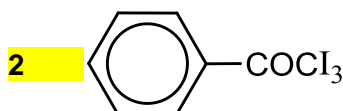
28 Which of the following pairs of compounds have the same structure and bonding?



- 1 Both have giant ionic structures.
- 2 AlCl_3 is simple molecular but MgCl_2 is giant ionic.
- 3 SiO_2 is giant covalent but CO_2 is simple molecular.

Answer: D

29 Which compound will produce CHI_3 on warming with alkaline $\text{I}_2(\text{aq})$?



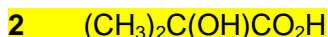
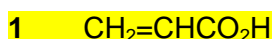
For positive tri-iodomethane test, there needs to be the presence of the methyl ketone, CH_3CO terminal group or methyl alcohol $\text{RCH}(\text{OH})\text{CH}_3$ group. The methyl group can be substituted with I.

For option 1, there is neither the methyl ketone nor the methyl alcohol groups present. Even if the ester group present did hydrolyse (which is possible because of the warm alkaline conditions), the products are not able to give positive triiodomethane test.

Therefore the only available answer is C (options 2 & 3).

30 An aldehyde is treated with HCN in the presence of a little KCN . The organic product is then heated under reflux with dilute sulfuric acid.

Which of the following is **not** likely to be a product or by-product of the above reaction?



Option 1 wrongly assumes that the sulfuric acid is able to perform dehydration at dilute concentrations.

Option 2 is the product from the reaction with a ketone, propanone. Hence it is **NOT** likely to be a product of a reaction between an aldehyde and HCN .

Option 3 is the product from the reaction between ethanal and HCN .

Answer: B