



CHEMISTRY

Paper 1 Multiple Choice

8873/01

24 September 2019

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your name, civics group and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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 question paper.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **12** printed pages.

- 1 Beams of charged particles are deflected by an electric field.

In an experiment, protons are deflected by an angle of $+15^\circ$. In another experiment, under identical conditions, particle X is deflected by an angle of -5° .

What could be the composition of particle X?

	protons	neutrons	electrons
A	1	2	2
B	2	3	3
C	3	3	4
D	4	5	1

Answer: **A**

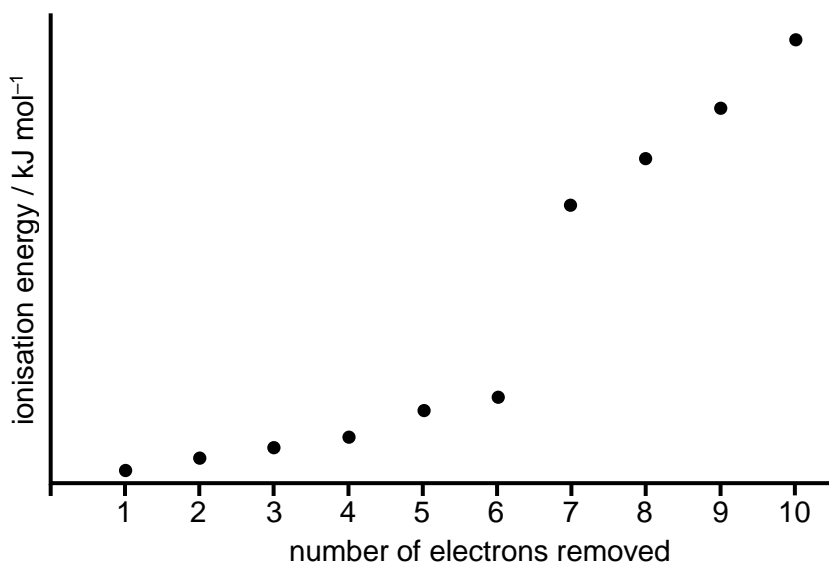
Angle of deflection, $\theta \propto \frac{Z}{m}$

For a proton, ${}^1_1\text{H}^+$, $\frac{Z}{m} = \frac{+1}{1} = +1$

For particle X, $\frac{Z}{m} = \frac{-5^\circ}{+15^\circ} (+1) = -\frac{1}{3}$

A: ${}^3_1\text{A}^-$; **B**: ${}^5_2\text{B}^-$; **C**: ${}^6_3\text{C}^{1-}$; **D**: ${}^9_4\text{D}^{3+}$

- 2 The graph represents the first ten ionisation energies of an element.



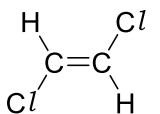
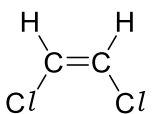
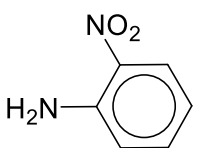
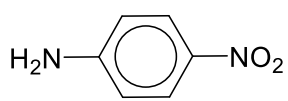
What is the element?

- A** C **B** S **C** Ne **D** Cl

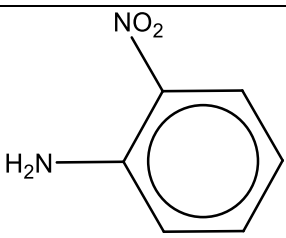
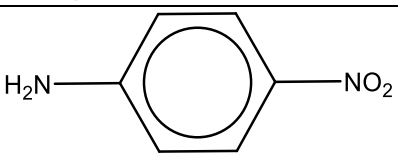
Answer: **B**

The element is from group 16 as there are 6 electrons in the outermost principal quantum shells. The 7th electron is removed from the inner principal quantum shell, hence the more significant increase in energy required to remove the 7th electron.

- 3 In which of the following pairs would compound **I** have a higher solubility in water than compound **II**?

	I	II
A		
B	CH ₃ COCH ₃	CH ₃ CH ₂ Cl
C	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CO ₂ H	CH ₃ CH ₂ CH ₂ CHClCH ₂ CO ₂ H
D		

Answer: **B**

	I	II
A	<i>trans</i> -CHCl=CHCl non-polar so lower solubility	<i>cis</i> -CHCl=CHCl polar so higher solubility
B	CH ₃ COCH ₃ O in propanone can form H-bond with water – so higher solubility	CH ₃ CH ₂ Cl
C	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ COOH	CH ₃ CH ₂ CH ₂ CHClCH ₂ COOH More polar
D	 Intramolecular hydrogen bonding between –NO ₂ and –NH ₂ group; leading to less extensive intermolecular hydrogen bonding with water, hence lower solubility	

4 C_2N is a very unstable molecule.

Assume that this molecule

- has a carbon-carbon-nitrogen sequence of atoms,
- is linear,
- has two π bonds.

What is the number of bonded pairs of electrons and unpaired electrons in one molecule of C_2N ?

	bonded pairs of electrons	unpaired electrons
A	2	1
B	2	2
C	3	2
D	4	1

Answer: **D**

	Proposed structures	
	$\text{C}=\text{C}=\text{N}$ $\cdot\cdot \text{C}=\text{C}=\ddot{\text{N}}\cdot$	$\text{C}-\text{C}\equiv\text{N}$ $\cdot\cdot \dot{\text{C}}-\text{C}\equiv\ddot{\text{N}}$
Bonded pairs	4	4
Unpaired electron	1	1

5 Which trends are correct across period 3 (from Na to Cl)?

- 1 atomic radius decreases
- 2 melting point increases
- 3 electronegativity increases
- 4 pH of the oxide solution increases

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

Answer: **A**

Across the period 3 elements,

- Number of protons increases, nuclear charge increases
- Shielding effect is negligible as electrons are added to the same shell
- Increase in electrostatic forces of attraction between the nucleus and valence electrons increases

Resulting in decrease in atomic radii, increase in electronegativity. Hence statement 1 and 3 is correct.

Statement 2 is wrong as the melting point of the element decreases across the period as the elements change from giant metallic to giant molecular and simple molecular structure. Statement 4 is wrong as the pH of the oxide decreases across the period as oxides change from basic ionic oxides to acidic covalent oxides.

- 6 The standard enthalpy change of formation of HCl and HI are -92 kJ mol^{-1} and $+26 \text{ kJ mol}^{-1}$ respectively.

Which statement best accounts for the difference?

- A Chlorine is more electronegative than iodine.
 B The activation energy for the reaction between H_2 and Cl_2 is much less than that between H_2 and I_2 .
 C The bond energy of HI is smaller than the bond energy of HCl .
 D The bond energy of I_2 is smaller than the bond energy of Cl_2 .

Answer: C

The bond energy of X-X bond does not account for the increase in value of enthalpy change of formation from HCl to HI . In fact, less energy is released from formation of H-X bond account for the increase in value of enthalpy change of formation from HCl to HI .

- 7 The relative atomic mass of antimony, which consist of the isotopes ^{121}Sb and ^{123}Sb , is 121.8. Calculate the percentage of ^{123}Sb in the isotopic mixture.

- A 40% B 45% C 50% D 60%

Answer: A

Let the percentage of ^{123}Sb in the isotopic mixture be $x\%$

$$\frac{x}{100} 123 + \frac{100-x}{100} 121 = 121.8$$

$$123x - 121x = 80$$

$$x = 40\%$$

- 8 A barium salt, BaFeO_n , reacts with hydrochloric acid to produce iron(III) ions and chlorine gas. In an experiment, 2 moles of BaFeO_n is reacted with excess hydrochloric acid to produce 3 moles of chlorine.

What is the value of n ?

- A 1 B 2 C 4 D 6

Answer: C

1 mol of BaFeO_n reacted to yield 1.5 mol of chlorine.



According to above, 3 mol of electrons is loss from the oxidation of Cl^- .

Thus, 3 mol of electrons is gained by FeO_n^{2-}



$$x = 6$$

$$\text{Hence } +6 + n(-2) = -2 \text{ and } \underline{n = 4}$$

- 9 Two 100 cm³ aqueous solutions, one containing 0.10 mol NaOH and the other 0.010 mol HCl have the same initial temperature.

When the two solution are mixed, the temperature rises by z °C. You may assume the specific heat capacity, c , of the reaction mixture is 4.18 J g⁻¹ K⁻¹ and the density of the reaction mixture is 1.00 g cm⁻³.

What is the enthalpy change of neutralisation in kJ mol⁻¹?

- A $\frac{200 \times 4.18 \times z}{1000 \times 0.11}$
- B $\frac{200 \times 4.18 \times z}{1000 \times 0.010}$
- C $\frac{100 \times 4.18 \times z}{1000 \times 0.010}$
- D $\frac{200 \times 4.18 \times (z + 273)}{1000 \times 0.010}$

Answer: B

$$\Delta H = + \frac{q}{n_{H_2O}} = + \frac{(100 + 100) \times 4.18 \times z}{1000 \times 0.010}$$

- 10 Phosphorus exists as different allotropes.

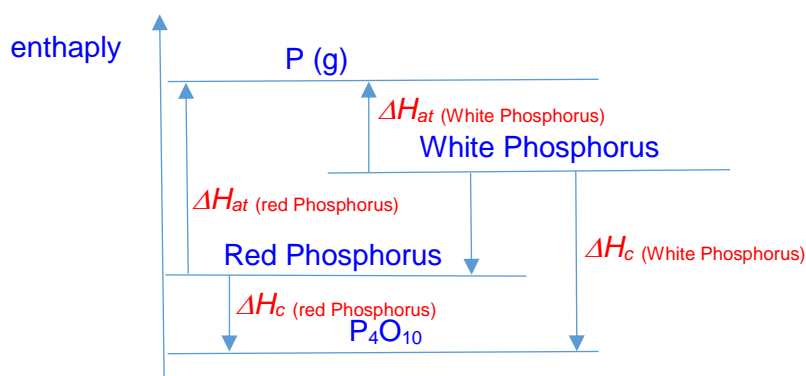
The enthalpy change for the conversion from white phosphorus to red phosphorus is -17.6 kJ mol⁻¹.

Which statements are correct?

- 1 The enthalpy change of atomisation of white phosphorus is more endothermic than that of red phosphorus.
- 2 The enthalpy change of combustion of white phosphorus is more exothermic than that of red phosphorus.
- 3 White phosphorus is more stable than red phosphorus.

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

Answer: **B**



- 11 The rate equation for the reaction $\mathbf{W(g)} + 2\mathbf{X(g)} \rightarrow 3\mathbf{Y(g)}$ is $\text{rate} = k[\mathbf{W}][\mathbf{X}]^2$.

By which factor will the rate of reaction increase when the concentration of **W** and **X** are each increased by a factor of 3?

- A** 9 **B** 27 **C** 81 **D** 108

Answer: **B**

Let the initial concentration of **W** and **X** be a and $b \text{ mol dm}^{-3}$ respectively

Initial Rate = $k[\mathbf{W}][\mathbf{X}]^2 = kab^2$

New rate = $k(3a)(3b)^2 = 27 kab^2$

- 12 Sodium carbonate and hydrochloric acid reacted in separately in two reactions.



Reaction 1: 1.0 g $\text{Na}_2\text{CO}_3(\text{s})$ added to 100 cm^3 of 0.50 mol dm^{-3} $\text{HCl}(\text{aq})$

Reaction 2: 1.0 g $\text{Na}_2\text{CO}_3(\text{s})$ added to 100 cm^3 of 2.0 mol dm^{-3} $\text{HCl}(\text{aq})$

Given $\text{rate} = k[\text{HCl}]$, which of the following is the same for both reactions?

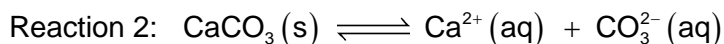
- A** Average rate of production of CO_2
B Initial rate of reaction
C Total mass of CO_2 produced
D Total reaction time

Answer: **C**

Since the reaction is 1st order w.r.t HCl , change in $[\text{HCl}]$ affects rate of reaction as well as reaction time.

The sodium carbonate is the limiting reagent in both reactions, hence the amount and mass of CO_2 produce is the same.

13 Two equilibria are shown.



The numerical value of K_c for reaction 1 is 2.2×10^{-8} .

Given the same conditions, what is the numerical value for K_c for reaction 2?

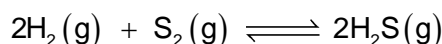
- A** 2.2×10^{-8} **B** 2.2×10^8 **C** 4.5×10^{-7} **D** 4.5×10^7

Answer: **D**

Reaction 2 is the reverse of reaction 1.

$$\text{Hence } K_c \text{ of reaction 2} = \frac{1}{K_c \text{ of reaction 1}} = \frac{1}{2.2 \times 10^{-8}} = 4.5 \times 10^7$$

14 At 700 °C, the equilibrium constant for the following reaction is 1.08×10^8 .



Which relationship is always correct for the equilibrium at this temperature?

- A** $[\text{S}_2] = 2[\text{H}_2\text{S}]$ **B** $[\text{S}_2] = [\text{H}_2\text{S}]^2$
C $[\text{H}_2\text{S}]^2 < [\text{H}_2]^2 [\text{S}_2]$ **D** $[\text{H}_2\text{S}]^2 > [\text{H}_2]^2 [\text{S}_2]$

Answer: **D**

Since K_c is very large, it means the forward reaction is very close to completion. There is more products than reactants.

15 Which is an example of an Arrhenius acid and Arrhenius base reaction?

- A** $2\text{CH}_3\text{COOH}(\text{aq}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightarrow \text{Ca}(\text{CH}_3\text{COO})_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
B $\text{CO}_2(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{CO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$
C $2\text{HCl}(\text{aq}) + \text{Na}_2\text{O}(\text{s}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
D $\text{HCl}(\text{g}) + \text{NH}_3(\text{g}) \rightarrow \text{NH}_4\text{Cl}(\text{g})$

Answer: **A**

An Arrhenius acid dissociates and releases H^+ when dissolved in water e.g $\text{HCl}(\text{aq})$

An Arrhenius base dissociates and releases OH^- when dissolved in water e.g $\text{Ca}(\text{OH})_2(\text{aq})$

- 16 The values of ionic product of water, K_w , at two different temperatures are given below.

temperature / °C	K_w / mol ² dm ⁻⁶
25	1.00×10^{-14}
100	5.50×10^{-13}

Which of the following statement is true for water at 100 °C?

- A** $[H^+] > [OH^-]$ **B** $[H^+] < [OH^-]$ **C** pH > 7 **D** pH < 7

Answer: **D**

A higher temperature favour the forward reaction according to the larger K_w value. Hence this means $[H^+]$ will increase to higher than 7.00×10^{-7} moldm⁻³, causing pH to be less than 7.

$$[H^+] = \sqrt{5.50 \times 10^{-13}} = 7.42 \times 10^{-7} \text{ moldm}^{-3}$$

- 17 The table shows the enthalpy change of neutralisation, ΔH_{neu} , for the various acids and bases listed.

acid	base	ΔH_{neu} / kJ mol ⁻¹
hydrobromic acid	sodium hydroxide	-57.0
hypochlorous acid	potassium hydroxide	less exothermic than -57.0
P	sodium hydroxide	less exothermic than -57.0
Q	potassium hydroxide	-57.0

What are **P** and **Q**?

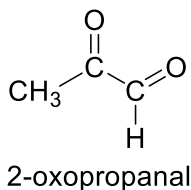
	P	Q
A	hydrochloric acid	nitric acid
B	ethanoic acid	hypochlorous acid
C	hydrocyanic acid	carbonic acid
D	ethanoic acid	hydrobromic acid

Answer: **D**

From the table, it can be deduced that hydrobromic acid is a strong acid since the enthalpy change of neutralisation is -57 kJ mol⁻¹. Hypochlorous acid is a weak acid since the enthalpy change of neutralisation is less exothermic than -57 kJ mol⁻¹.

Hence, **P** and **Q** must be weak and strong acid respectively.

- 18 2-Oxopropanal is one of the compounds responsible for the characteristic smell of burnt sugar.



How many σ and π bonds are there in a molecule of 2-oxopropanal?

	σ	π
A	5	2
B	7	0
C	8	2
D	10	0

Answer: **C**

- 19 The three statements that follow are all true.

Which of these can be explained by reference to hydrogen bonding?

- 1 Ice floats on water.
- 2 Propan-2-ol is less volatile than propanone.
- 3 The relative molecular mass of ethanoic acid in benzene is higher than expected.

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

Ans: **A**

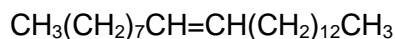
- Statement 1: In ice, each H_2O molecule forms the maximum of **four** hydrogen bonds with 4 other H_2O molecules. This results in a **tetrahedral arrangement** and **open structure** of ice [with empty spaces between some H_2O molecules]. Due to its open structure, ice is **less dense** than water and so, **floats** on water.
- Propan-2-ol is an alcohol, it can form intermolecular hydrogen bonds. Propanone is a ketone. It has a polar $\text{C}=\text{O}$ bond and can form intermolecular permanent-dipole permanent dipole interactions. More energy is required to overcome stronger hydrogen bonding, hence propan-2-ol has higher boiling point, i.e. less volatile (less likely to evaporate).
- In benzene, ethanoic acid exists as a dimer. Hence its apparent M_r is 120, instead of 60.

- 20 How many dichlorinated structural isomers can be formed by the chlorination of butane in the presence of UV light?

A 4 B 5 C 6 D 7

Answer: C

- 21 Muscalure is a sex hormone found in fruit flies and has the structure below.



Which of the following about muscalure is correct?

- A It reacts with LiAlH_4 .
 B It reacts with 2 moles of H_2 .
 C It exists as a pair of *cis-trans* isomers.
 D It reacts with HBr to give $\text{CH}_3(\text{CH}_2)_7\text{CH}_2\text{CHBr}(\text{CH}_2)_{12}\text{CH}_3$ only.

Answer: C

The rest of the statements are incorrect.

- Statement A: LiAlH_4 is unable to reduce alkenes.
- Statement B: It reacts with 1 mol of H_2 , not 2mol.
- Statement D: It reacts with hot acidified KMnO_4 to give $\text{CH}_3(\text{CH}_2)_7\text{CO}_2\text{H}$ as one of the products

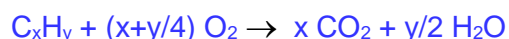
- 22 Complete combustion of a sample of a hydrocarbon gave 0.132 g of carbon dioxide and 0.054 g of water. Which of the following formulae could correctly represent this hydrocarbon?

Which of the following could be Z?

- 1 $\text{CH}_2=\text{CH}_2$
 2 $\text{CH}_3\text{CH}=\text{CH}_2$
 3 $\text{CH}_3\text{CH}=\text{CHCH}_3$

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

Answer: A



$$\text{Amt. of CO}_2 = 0.132/44 = 0.003 \text{ mol}$$

$$\text{Amt. of H}_2\text{O} = 0.054/18 = 0.003 \text{ mol}$$

$$\text{Therefore, } x = y/2. \text{ } y=2x$$

- 23 The following table shows the time taken for the appearance of precipitate after adding ethanolic AgNO_3 to three halogen derivatives separately.

halogen derivative	time for precipitate to appear
2-chloropropane	10 minutes
2-bromopropane	2 minutes
2-iodopropane	instantaneous

Which of the following would be the best explanation for the observation?

- A The bond polarity of the carbon-halogen bond increases from 2-iodopropane to 2-chloropropane.
- B The lattice energy of AgX precipitate becomes more exothermic from AgCl to AgI .
- C The carbon-halogen bond strength decreases from 2-chloropropane to 2-iodopropane.
- D The intermolecular permanent dipole attraction increases from 2-iodopropane to 2-chloropropane.

Answer: C

The reaction involves breaking of the $\text{C} - \text{X}$ bond.



\therefore Rate of hydrolysis depends on strength of $\text{C} - \text{X}$ bond.

Once the $\text{C} - \text{X}$ bond is broken, precipitation of AgX(s) occurs.



The time taken for silver halide precipitates to form indicates the strength of the $\text{C} - \text{X}$ bond, where X is Cl, Br or I.

Time taken for ppt. to appear:

2-chloropropane > 2-bromopropane > 2-iodopropane

Bond strength: $\text{C} - \text{Cl} > \text{C} - \text{Br} > \text{C} - \text{I}$

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

Infra-red absorptions can be used to identify functional groups in organic compounds. For example, ethyl ethanoate shows absorptions at $1050\text{--}1330\text{ cm}^{-1}$ and $1710\text{--}1750\text{ cm}^{-1}$ as shown in the *Data Booklet*.

Compound **S** contains four carbon atoms. **S** is heated under reflux with an excess of acidified dichromate(VI) until no further reaction occurs. An organic compound **T** is formed in good yield. Some of the absorptions found in the infra-red spectra of **S** and **T** are described.

S has **no** strong absorption between 1670 and 1740 cm^{-1} .

T has strong absorptions both at approximately 1710 cm^{-1} and at approximately 3400 cm^{-1} .

From this information, what could be the structure of **S**?

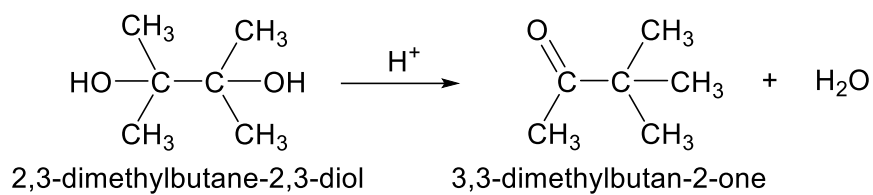
- A $\text{HOC}(\text{CH}_3)_2\text{CHO}$
- B $\text{HOC}(\text{CH}_3)_2\text{CH}_2\text{OH}$
- C $\text{HO}(\text{CH}_2)_2\text{COCH}_2\text{OH}$
- D $\text{HO}(\text{CH}_2)_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$

Answer: **B**

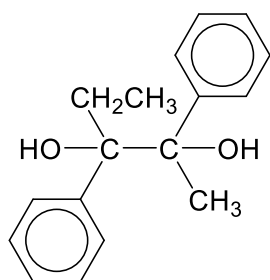
Based on data given for **S** (**no** strong absorption between 1670 and 1740 cm^{-1}), absence of aldehydes and ketones in **S**. *Not Option A or C.*

Based on data given for **T** (strong absorptions both at approximately 1710 cm^{-1} and at approximately 3400 cm^{-1}), presence of alcohol group even after oxidation. Presence of tertiary alcohol. Thus, **option B is correct.**

- 25 The pinacol rearrangement involves the reaction of a diol in acidic conditions to form a carbonyl compound as shown below.

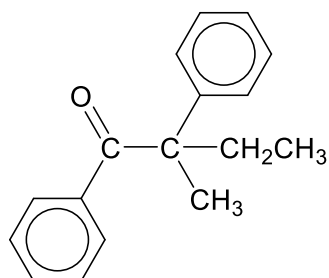


Which of the following structural formulae is **not** a product of the pinacol rearrangement of 2,3-diphenylpentane-2,3-diol?

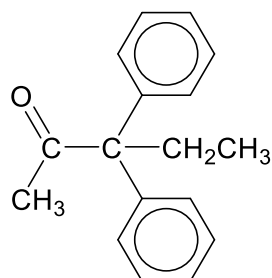


2,3-diphenylpentane-2,3-diol

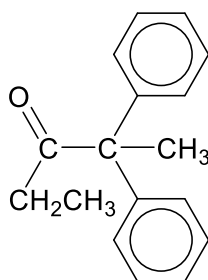
A



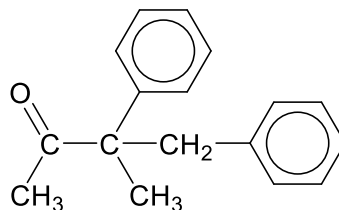
B



C

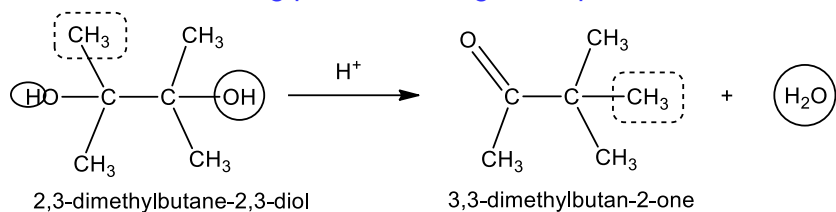


D



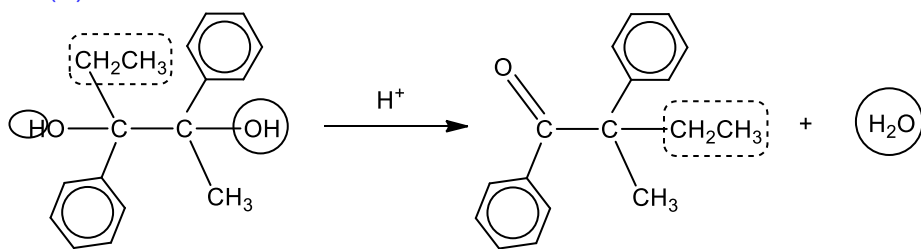
Answer: **D**

Observe the following pattern in the given equation.

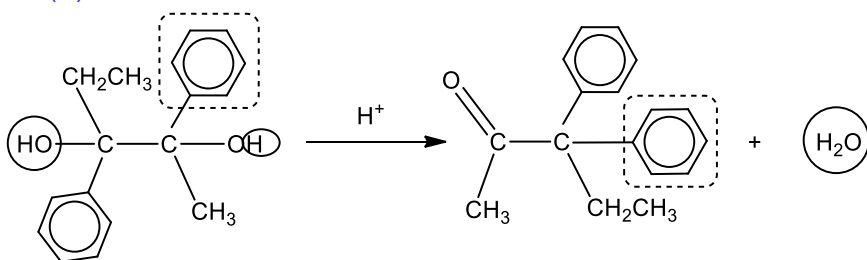


By applying the above pattern to 2,3-diphenylpentane-2,3-diol, option **D** is **not** a possible product of this reaction.

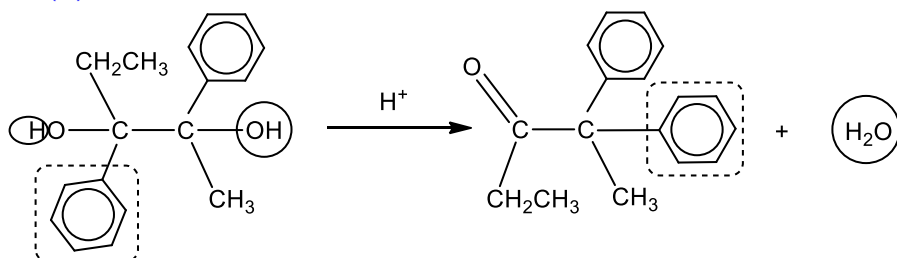
A : (×)



B : (×)

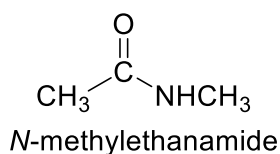


C : (×)



D : (✓) **Not** a possible product since group is absent in 2,3-diphenylpentane-2,3-diol.

- 26 Which molecules are best used for the synthesis of *N*-methylethanamide, in the presence of DCC?

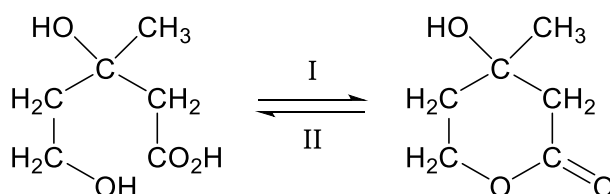


- A** CH_3COOH and CH_3NH_2 **B** CH_3CONH_2 and CH_3OH
C CH_3CHO and CH_3NH_2 **D** CH_3CHO and CH_3Br

Answer: **A**

To form an amide, the reagents needed are a carboxylic acid and an amine, in the presence of DCC.

- 27 Mevalonic acid, 3,5-dihydroxy-3-methylpentanoic acid, is involved in cholesterol formation in the body. It is an oil that occurs as a mixture of the two interchanging molecules shown in the diagram.



What names are used to describe the pair of interchanging reactions I and II respectively?

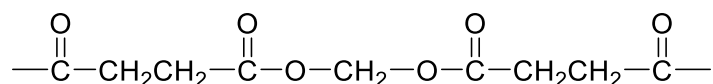
- A** condensation and addition
B condensation and hydrolysis
C neutralisation and acidification
D reduction and addition

Answer: **B**

Reaction I involves forming an ester bond \Rightarrow condensation

Reaction II involves breaking an ester bond \Rightarrow hydrolysis

28 Part of the structure of the polymer is shown below.



Which monomers could be used to make the polymer?

- 1 $\text{HO}_2\text{C—CH}_2\text{CH}_2\text{—CO}_2\text{H}$
- 2 $\text{HO—CH}_2\text{—OH}$
- 3 $\text{HO}_2\text{C—CH}_2\text{CH}_2\text{—OH}$
- 4 $\text{HO}_2\text{C—CH}_2\text{—CO}_2\text{H}$

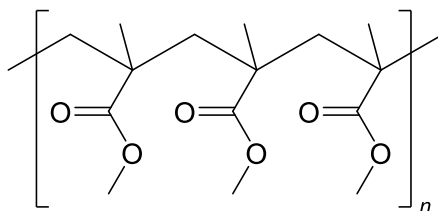
A 1 and 2 only **B** 2 and 3 only **C** 3 only **D** 4 only

Answer: **A**

The polymer is formed via condensation polymerisation given the presence of ester linkages. The original monomers were an acid and alcohol.

Looking at the centre segment of the polymer chain, it can be seen that the monomers were made up of a diol and dicarboxylic acid.

29 Poly(methyl methacrylate) is used to make hard contact lenses. Part of its polymer chain is shown.



Which statement about poly(methyl methacrylate) is correct?

- A** It is a polyester.
- B** It is a condensation polymer.
- C** It is resistant to alkaline hydrolysis.
- D** Its monomer is $\text{CH}_2=\text{C}(\text{CH}_3)\text{CO}_2\text{CH}_3$.

Answer: **D**

A: It has ester linkages but it is not a polyester where the ester linkage is not part of the polymeric chain.

B: It is an addition polymer

C: The ester linkage can be hydrolysed.

- 30** Catalytic converters make use of platinum, rhodium and palladium to speed up the conversion of pollutants into non-toxic emissions.

In 2007, Mazda Motor developed a new generation of catalytic converters that halved the size of metal nanoparticles (10 nm to 5 nm) utilised in conventional ones. A key benefit of this new technology was cost savings for car manufacturers, since these metals are expensive due to their limited supplies.

Based on your own knowledge and the information above, which statement about nanoparticle-based catalytic converters is **not** correct?

- A** Nanoparticles are good catalysts due to its large surface area to volume ratio.
- B** Less of these metals is needed to produce these catalytic converters, resulting in cost savings.
- C** With the reduced size of nanoparticles, they could be more safely used in catalytic converters because it has less harmful effects on human health.
- D** The metal nanoparticles catalyse the conversion of nitrogen oxides and hydrocarbons into nitrogen and carbon dioxide gases respectively.

Answer: **C**

A: The smaller the size of the particle, the larger the surface area to volume ratio.

B: With the reduced size of nanoparticles, due to the increased surface area to volume ratio, a larger proportion of the metal is present on the surface of the given catalyst, leading to greater no. of active sites and hence increasing catalytic efficiency.

Less metal is needed for a smaller size nanoparticle to produce the same surface area over the catalyst for the same catalytic efficiency.

C: Smaller nanoparticles pose a more serious issues since they could penetrate even more in-depth into the interior of the body tissues and cell membranes, which can cause potential harmful effects within the human body.

D: Correct. **Pd(s) & Pt(s)** promote the oxidation of CO and unburnt hydrocarbons to CO₂ & H₂O. **Rh(s)** promotes the reduction of NO to N₂.

2019 H1 P1 Answer :

Question	Answer	Question	Answer
1	A	16	D
2	B	17	D
3	B	18	C
4	D	19	A
5	A	20	C
6	C	21	C
7	A	22	A
8	C	23	C
9	B	24	B
10	B	25	D
11	B	26	A
12	C	27	B
13	D	28	A
14	D	29	D
15	A	30	C



EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2019
General Certificate of Education Advanced Level
Higher 1

CANDIDATE
NAME

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CIVICS
GROUP

1	8	-		
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INDEX
NUMBER

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CHEMISTRY

Paper 2 Structured Questions

8873/02

17 September 2019

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

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

Section A

Answer **all** the questions.

Section B

Answer **one** question.

The use of an approved scientific calculator is expected, where appropriate.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
Section A (60 marks)	
1	/ 10
2	/ 8
3	/ 11
4	/ 15
5	/ 5
6	/ 11
Section B (20 marks)	
	/ 20
Total	/ 80

This document consists of **24** printed pages.

Section A

Answer **all** the questions in this section in the spaces provided.

For
Examiner's
Use

- 1 (a) Describe the structure of a ^{21}Na atom, in terms of number and type of subatomic particles.

There are 11 electrons, 11 protons and 10 neutrons. [1]

Comments:

- This part was well done in general.

- (b) Explain why atomic radius decreases from sodium to chlorine across Period 3.

Across the period, atomic radii decrease because:

Nuclear charge increases.

Shielding effect is similar since successive elements in the period have an additional electron in the same valence shell.

Effective nuclear charge increases. There are stronger electrostatic forces of attraction between the nucleus and the valence electrons [3]

Comments:

- This part was well done in general.
- Common mistakes: "Shielding effect is negligible."

- (c) With reference to the *Data Booklet*, explain why the atomic radius and ionic radius of sodium differ.

Nuclear charge remains the same.

The Na^+ cation has one principal quantum shell lesser than the Na atom.

or The valence electrons in Na^+ are closer to the nucleus.

There are stronger electrostatic forces of attraction between the nucleus and the valence electrons in Na^+ . [2]

Comments:

- Most students forgot to mention "nuclear charge remains unchanged."

- (d) Negligence of chemical manufacturing companies or chemical waste disposable companies can cause serious health and environment hazard. An example of a chemical fire was mentioned in a news report:

Sodium Drum Blaze Scare

A 20 litre drum containing sodium burst into flames when it reacted violently with rainwater at a Manchester factory. It is believed that the sodium, which is normally stored under oil, had been accidentally left outside with the lid off.

A factory worker put out the blaze before the fire services arrived, and a leading fire fighter said, "It was fortunate that potassium wasn't involved as it would have reacted more violently and exploded. These Group 1 alkali metals can be very dangerous".

- (i) Suggest why Group 1 metals are stored under oil.

Group 1 metals readily oxidises. Hence oil acts as a barrier between sodium and air/oxygen/water. [1]

Comments:

- This part was well done in general.

- (ii) Write an equation for the reaction of sodium with water.

$2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$ [1]

Comments:

- Many students wrongly state the product formed as "Na₂O"

- (iii) Explain why potassium reacts more violently than sodium.

Down the group, the atomic radius increases. There is weaker electrostatic force of attraction between the nucleus and valence electrons.

Potassium atoms lose their valence electrons to form K⁺ cations more easily.

Hence, potassium have greater tendency to be oxidised / reducing power increases.

Additionally, as reflected by the melting point trend, the weaker metallic bond leads to lower activation energies and hence faster reactions. [2]

[Total: 10]

Comments:

- This part was not answered completely by most students. Students are expected to link the reactivity towards reducing power/ease of oxidation

- 2 Potassium iodate, KIO_3 , and potassium iodide, KI , was reacted in the presence of acid to form iodine, I_2 .

- (a) (i) Identify the oxidising and reducing agent in the above reaction and state its change in oxidation number.

role in the reaction	species	change in oxidation number
oxidising agent	IO_3^-	from <u>+5</u> to <u>0</u>
reducing agent	I^-	from <u>-1</u> to <u>0</u>

[2]

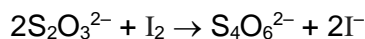
- (ii) Write a balanced equation for the reaction of KIO_3 and KI .



Comments:

- This part was poorly done. Many students could not identify the O.A and R.A and write the corresponding equations.
- Many wrongly thought that K^+ is involved in the redox.

- (b) 1.50 g of a solid mixture of KIO_3 and KI was dissolved in acid and made up to 250 cm^3 using distilled water. 25.0 cm^3 of the solution was then titrated with sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.



22.45 cm^3 of $0.0250 \text{ mol dm}^{-3}$ of $\text{Na}_2\text{S}_2\text{O}_3$ to completely react with the I_2 formed.

- (i) Calculate the amount of iodine produced in the reaction.

$$\begin{aligned} \text{amount of } \text{I}_2 \text{ in } 25.0 \text{ cm}^3 \text{ solution} &= 0.0250 \times \frac{22.45}{1000} \times \frac{1}{2} \\ &= 2.806 \times 10^{-4} \text{ mol} \\ \text{amount of } \text{I}_2 \text{ in } 250 \text{ cm}^3 \text{ solution} &= 2.806 \times 10^{-4} \times \frac{250}{25.0} \\ &= 2.806 \times 10^{-3} \approx \underline{2.81 \times 10^{-3} \text{ mol}} \end{aligned}$$

[2]

Comments:

- This part was well done in general.
- Some students read the question wrongly and calculated amt of I_2 in 25.0 cm^3 only.

- (ii) Hence, calculate the percentage composition by mass of potassium iodate in the mixture. You may assume that KI is in excess.

$$\begin{aligned}
 \text{amount of IO}_3^- \text{ in } 1.50 \text{ g} &= \frac{1}{3} \times 2.806 \times 10^{-3} \\
 &= 9.353 \times 10^{-4} \text{ mol} \\
 \text{mass of KIO}_3 \text{ in } 1.50 \text{ g} &= 9.353 \times 10^{-4} \times (39.1 + 126.9 + 48.0) \\
 &= 0.2002 \text{ g} \\
 \text{percentage of KIO}_3 \text{ by mass} &= \frac{0.2002}{1.50} \times 100\% \\
 &= \underline{13.3\%}
 \end{aligned}$$

Comments:

- This part was well done in general.

[2]

- (c) Explain why the redox reaction cannot take place if a sample of KIO₃ and potassium chloride, KCl, was dissolved in the presence of acid.

Reducing ability of the halide ions increases as you go down the Group. Cl⁻ is a weaker reducing agent than I⁻. Hence Cl⁻ will not be able to reduce IO₃⁻ / the redox reaction will not happen.

[1]

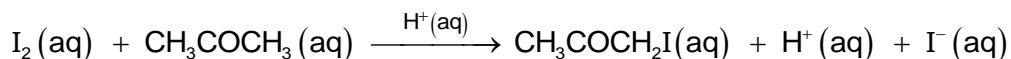
Comments:

- This part was poorly done in general.
- Many students did not relate the difference between the given redox reactions is the KCl, instead of KI. Hence should link to reactivity of halides in redox reactions.

[Total: 8]

- 3 The rate of the acid-catalysed iodination of propanone can be followed by monitoring changes in iodine concentration with time.

For
Examiner's
Use



The reaction is zero order with respect to iodine and first order with respect to propanone.

- (a) In a particular experiment shown in Fig. 3.1 below, concentration of propanone was 1.00 mol dm^{-3} and concentration of acid was 1.50 mol dm^{-3} .

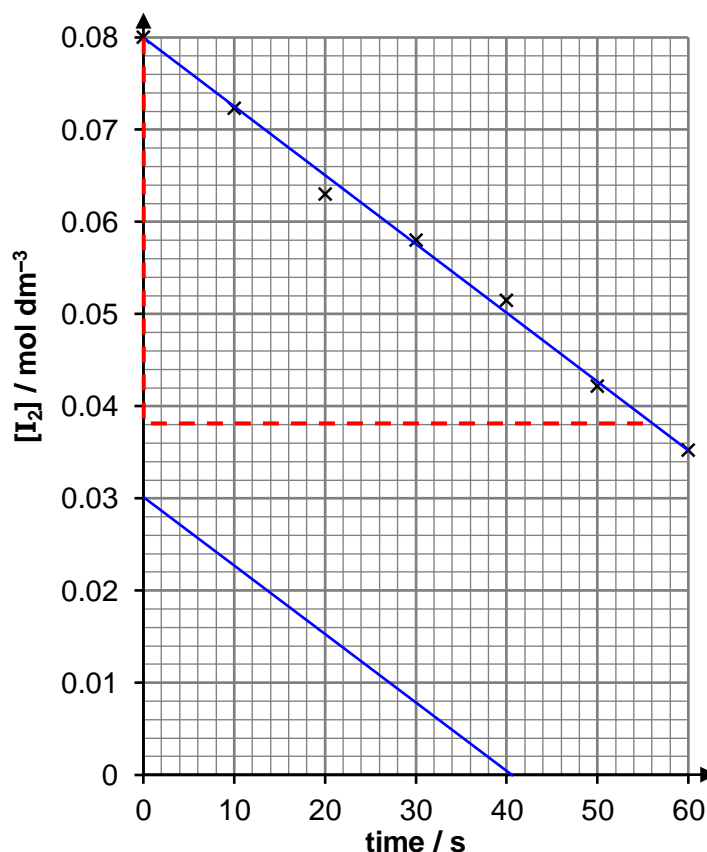


Fig. 3.1

- (i) Determine the rate of reaction in the experiment.

Draw best fit straight line

$$\text{rate} = -\frac{\Delta y}{\Delta x} = -\frac{0.080 - 0.038}{0 - 56} = \underline{0.000750 \text{ mol dm}^{-3} \text{ s}^{-1}}$$

[2]

- (ii) Sketch on the same graph in Fig. 3.1, the expected graph when the reaction was repeated with 0.03 mol dm^{-3} of iodine.

Draw straight line with the same gradient calculated in (a)(i)

[1]

Comments:

- This part was poorly done in general.
- Many students did not draw the best fit line and lost subsequent marks.

- (b) Further experiments with varying concentration of acids were conducted. The concentration of iodine and propanone was kept constant.

[acid] / mol dm ⁻³	rate of reaction / mol dm ⁻³ s ⁻¹
0.50	0.00025
1.00	0.00049

- (i) Deduce the order of reaction with respect to acid.

When concentration of acid is doubled, rate double.

Hence, it is first order with respect to acid. [2]

Comments:

- This part was well done in general.

- (ii) Suggest why it is not possible to deduce order of reaction with respect to acid based on the graph in Fig. 3.1 only.

For this reaction, H⁺ is a catalyst and the concentration of H⁺ produced is

much smaller than the original concentration. The H⁺ concentration did not

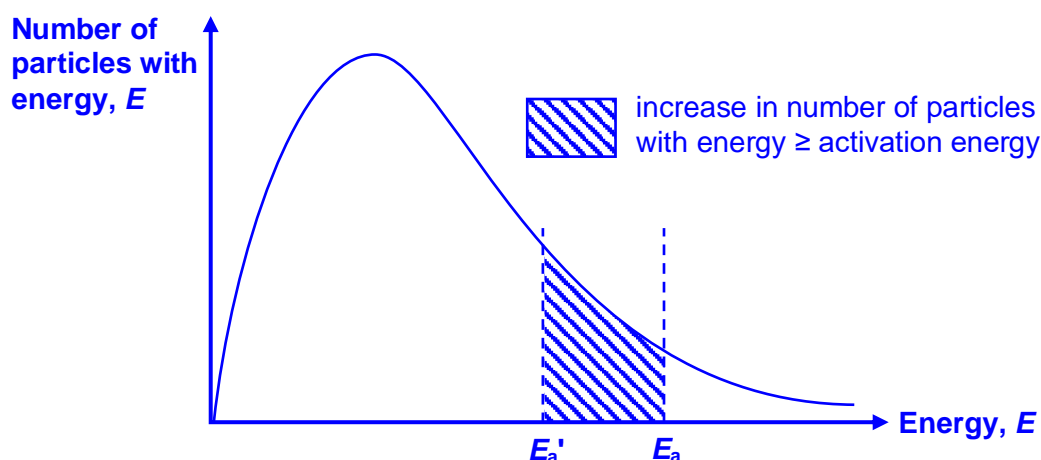
change over the course of the experiment. Hence no conclusion about the effect

of H⁺ on rate of reaction [1]

Comments:

- This part was poorly done in general.

- (c) Explain in detail the effect of the acid catalyst on the rate of reaction. Illustrate your answer with an appropriate sketch of the Boltzmann distribution.



When a catalyst is used, the reaction proceeds via a pathway of **lower activation energy**, E_a' . The number of reacting particles possessing **energy greater than or equal to the activation energy** increases. The **frequency of effective collisions** increases, and hence the rate of reaction increases. [3]

Comments:

- This part was well done in general.
- A few students still draw the wrong graph or have missing labels.

- (d) When the reaction was carried out in the absence of acid, the graph in Fig. 3.2 is obtained.

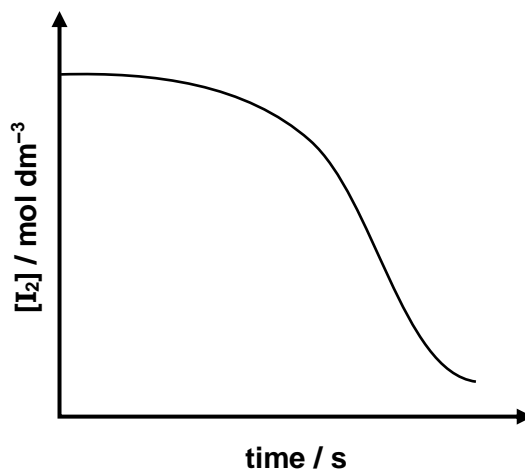


Fig. 3.2

Account for the shape of the graph.

Initially there is **slow rate** of reaction as there was **no acid catalyst**. The rate of reaction **increases** after some of **the product H^+ is formed and catalyses reaction**.

[2]

Comments:

- This part was poorly done in general.
- Students were expected to link the change in gradient to the action of H^+ as catalyst.

[Total: 11]

- 4 Sorbic acid is named after the *Sorbus aucuparia* tree and can be isolated from the tree's berries. It is commonly used as a food preservative.



sorbic acid

- (a) Name the type of stereoisomerism that could be present in sorbic acid, and state the number of isomers.

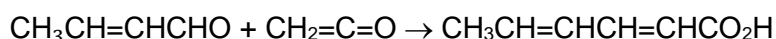
Type of isomerism: cis-trans isomerism

Number of isomers: 4 [1]

Comments:

- This part was well done in general. But some students wrongly thought that structural isomerism was present.

- (b) Commercially, sorbic acid is produced from crotonaldehyde and ethenone.



crotonaldehyde

ethenone

sorbic acid

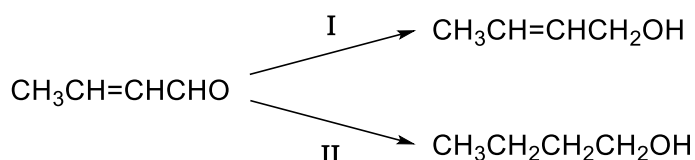
- (i) Suggest the type of reaction in the above equation.

addition [1]

Comments:

- This part was well done in general.

- (ii) Crotonaldehyde can be converted into the following compounds.



State the reagent and conditions required for reactions **I** and **II**.

I: LiAlH_4 in dry ether or NaBH_4 in ethanol

II: H_2 , Ni, heat [2]

- (iii) Name the product formed in reaction **II**.

Butan-1-ol [1]

Comments:

- Part (ii) and (iii) was well done in general.

- (iv) Crotonaldehyde reacts with bromine in organic solvent. State the expected observations, and write the structural formula of the product formed.

Observations: Orange solution decolourises

Product: $\text{CH}_3\text{CHBrCHBrCHO}$ [2]

Comments:

- This part was well done in general. But some students state the wrong colour for Br_2 in organic solvent

- (c) Explain whether you would expect sorbic acid to be soluble in the following.

- (i) water

Sorbic acid is **not** soluble in water due to its **long non-polar alkyl chain**.

Accept soluble in water due to ion-dipole interactions/hydrogen bonds formed [1]

between water and $-\text{COOH}$ group of sorbic acid.

- (ii) $\text{NaHCO}_3(\text{aq})$

Sorbic acid is **soluble** in NaHCO_3 due to an **acid-base reaction to form a soluble**

salt. [1]

Comments:

- This part was poorly done in general. Many students were unable to see the chemical reaction between sorbic acid and NaHCO_3 .

In an experiment to determine the concentration of a solution of sorbic acid, 25.0 cm^3 of sorbic acid was titrated against $0.30 \text{ mol dm}^{-3} \text{ NaOH}(\text{aq})$ at 25°C .

- (d) In the experiment, 20.20 cm^3 of NaOH solution is required for complete neutralisation.

- (i) Calculate the molar concentration of the sorbic acid solution.

$$\begin{aligned}\text{amount of sorbic acid} &= \text{amount of NaOH} \\ &= 0.30 \times 0.0202 \\ &= 6.06 \times 10^{-3} \text{ mol}\end{aligned}$$

$$[\text{sorbic acid}] = \frac{6.06 \times 10^{-3}}{\frac{25.0}{1000}} = \underline{\underline{0.242 \text{ mol dm}^{-3}}}$$

[1]

Comments:

- This part was well done in general.

- (ii) Given that the pH of the sorbic acid solution is 2.69, explain whether sorbic acid is a strong acid or weak acid.

$$[\text{HA}] = 0.242 \text{ mol dm}^{-3}$$

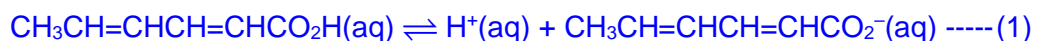
$$[\text{H}^+] = 10^{-2.69} = 2.04 \times 10^{-3} \text{ mol dm}^{-3}$$

Since $[\text{HA}] \gg [\text{H}^+]$, sorbic acid is a weak acid, which dissociates partially in solution to give a low $[\text{H}^+]$. [1]

Comments:

- This part was poorly done in general.
- There were incomplete answers that did not show working to prove the strength of acid.
- Many wrongly link strength of acid to the pH value.

- (iii) Suggest, with reasoning, whether you would expect the same titre value if 25.0 cm³ of hydrochloric acid with the same concentration as that of sorbic acid in (d)(i) was used instead.



When the sodium hydroxide reacts with H^+ , $[\text{H}^+]$ decreases.

By Le Chatelier's Principle, equilibrium position in (1) will shift right to increase the $[\text{H}^+]$. Hence, reaction (1) will eventually go to completion.

The no. of moles/ amount of H^+ used eventually in each case will be the same as the no. of moles of HA and HCl are the same. Hence, the titre value will be the same. [2]

Comments:

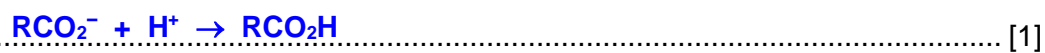
- This part was poorly done in general. Many thought that since HCl is a strong acid, the titre volume is larger.

- (e) A buffer solution is formed when 10.00 cm³ of NaOH solution is added to the original sorbic acid solution instead.

- (i) Explain what is meant by a *buffer solution*.

A buffer solution is a solution which is able to resist a change in pH (i.e. pH remains almost unchanged) when a small amount of acid or base is added to it. [1]

- (ii) Write an equation for the reaction that occurs when 1 drop of nitric acid is added to this buffer solution. You may represent sorbic acid as RCO_2H .



Comments:

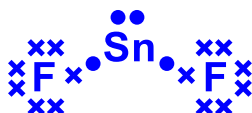
- Some students were unable to identify the correct buffer component.

[Total: 15]

- 5 Toothpaste is a paste or gel used to clean and maintain the aesthetics and health of teeth. The additional fluoride in toothpaste has beneficial effects on the formation of dental enamel and bones. Sodium fluoride, NaF, is the most common source of fluoride but tin(II) fluoride, SnF_2 , can also be used.

Sodium fluoride has a very high melting point of 993°C whereas tin(II) fluoride has a low melting point of 215°C .

- (a) Draw the dot-and-cross diagram of tin(II) fluoride, stating its shape and bond angle.



Shape: Bent / V-shaped

Bond angle: 118° (any value between 110° – 119°) [2]

Comments:

- Some students drew the wrong structure.

- (b) Explain, in terms of structure and bonding, the difference in melting points of sodium fluoride and tin(II) fluoride.

Sodium fluoride has a giant ionic (lattice) structure with strong electrostatic forces of attraction between oppositely charged ions / Na^+ and F^- ions. A larger amount of energy is required to overcome the electrostatic forces of attraction.

Tin(II) fluoride is a polar simple molecular/covalent molecule with permanent dipole-permanent dipole attraction between molecules. A smaller amount of energy is required to overcome the pd-pd attraction. [2]

Comments:

- This part was poorly done in general.
- Quite a few wrongly thought that SnF_2 is ionic (despite drawing the dot and cross in (a)).
- There were incomplete answers as well as wrong usage of the term “Van De Waals”

- (c) In the vapour phase, SnF_2 forms the dimer, Sn_2F_4 . Explain why the dimer is formed, given that it has the structure similar to that of aluminium chloride, Al_2Cl_6 .

Sn in SnF_2 is electron deficient / has empty orbitals to accept the lone pair of electrons in F to form dative bond.

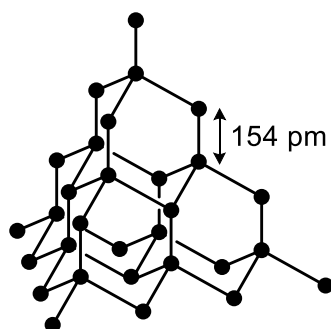
[1]

Comments:

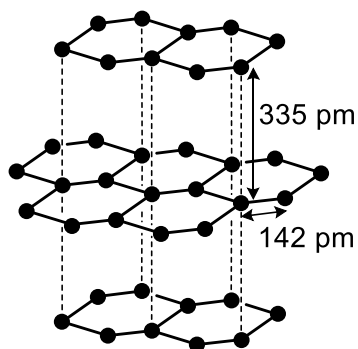
- This part was poorly done in general.
- While there were some incomplete answers, majority of students were not able to link the formation of dative bonds despite the clue given in the question.

[Total: 5]

- 6 (a) The structures of two allotropes of carbon are shown.



diamond



graphite

- (i) With reference to these structures, explain the meaning of the term *allotropes*.

Forms of the same element with different structures

[1]

Comments:

- Some students wrongly gave the definition for isomer.

- (ii) State and explain the difference in the hardness and electrical conductivity of these allotropes.

Hardness: Diamond is hard while graphite is soft. A larger amount of energy is needed to break the strong covalent bonds between C atoms in diamond, whereas in graphite, a smaller amount of energy is needed to overcome the weak intermolecular instantaneous dipole-induced dipole interactions between layers of carbon atoms.

Electrical conductivity: Diamond cannot conduct electricity while graphite can. In diamond, there are no mobile charged carriers. However in graphite, there are mobile/delocalised electrons along the hexagonal layers of carbon atoms. [4]

Comments:

- This part was poorly done in general.
- There were many incomplete answers as students were expected clearly compare both diamond and graphite.

- (b) In 2012, the Nobel Prize for Physics was awarded to two researchers from Manchester University for their work on preparing graphene, a nanomaterial from graphite.

In recent years, graphene and its derivatives have attracted increasing attention in making antibacterial materials. Antibacterial nanomaterials possess the ability to inhibit the growth of the bacteria and widely used in biomedical devices such as the heart pacemaker.

Conventionally, silver nanoparticles were used in these biomedical devices. However, they have certain drawbacks such as high cost, toxicity to the environment, and problems in disposal of the wastes.

- (i) State the difference between a nanoparticle and a nanomaterial in terms of size.

Nanoparticles ALL dimensions 1–100 nm/on the nanoscale
AND nanomaterial (at least) one dimension 1–100 nm/on the nanoscale [1]

Comments:

- This part was well done in general.

- (ii) Describe the structure of graphene. Explain how this structure gives graphene the properties of high tensile strength and high electrical conductivity.

You may find it useful to include labelled diagrams in your answer.

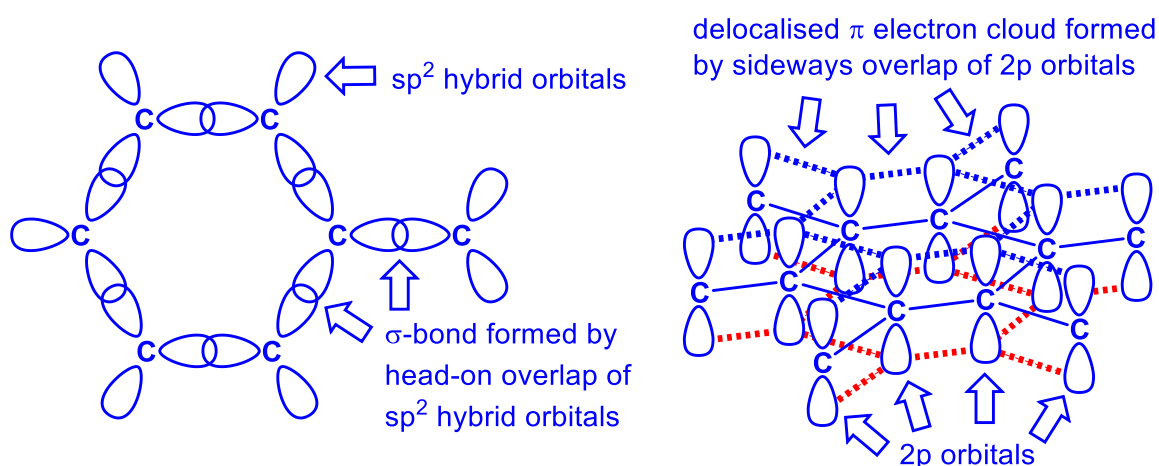
Graphene has a single layer hexagonal lattice structure.

Each carbon atom will overlap head/end-on with 3 other carbon atoms to form

3 strong covalent bonds. Hence, it has high tensile strength. or diagram

Each carbon atom also has an electron in the p orbital that can delocalise with

neighbouring carbon atoms. Hence it can conduct electricity. or diagram



Comments:

- This part was poorly done in general.
- There were some incomplete answers as students did not fully describe the structure of graphene.

[3]

- (iii) Graphene can be prepared from graphite by using sticky tape. The researchers realised by repeatedly sticking and peeling back the tape from graphite they could get down to the thinnest of all possible layers, one atom thick.

Use your knowledge of bonding in graphite to explain why it is possible to create graphene by this method.

There are weak instantaneous dipole-induced dipole attractions between
graphene sheets in graphite. [1]

Comments:

- This part was well done in general.

- (iv) It has been observed that in general, silver nanoparticles with an average size of 10 nm or less greatly increase their antibacterial activity. Explain briefly why this is so.

For
Examiner's
Use

Smaller particles have greater/larger surface area to volume ratios, resulting
in a higher proportion of the particles at the surface being able to react leading
to increased antibacterial activity. [1]

Comments:

- This part was well done in general.

[Total: 11]

Section B

Answer **one** question from this section in the spaces provided.

For
Examiner's
Use

- 7 Phosphorus pentachloride, PCl_5 , and phosphorus trichloride, PCl_3 , are used as starting materials for synthesis of a variety of inorganic and organic phosphorus compounds such as pesticides, fertilisers and food additives.
- (a) PCl_5 has trigonal bipyramidal shape about P. A trigonal bipyramidal arrangement is shown in Fig 6.1.

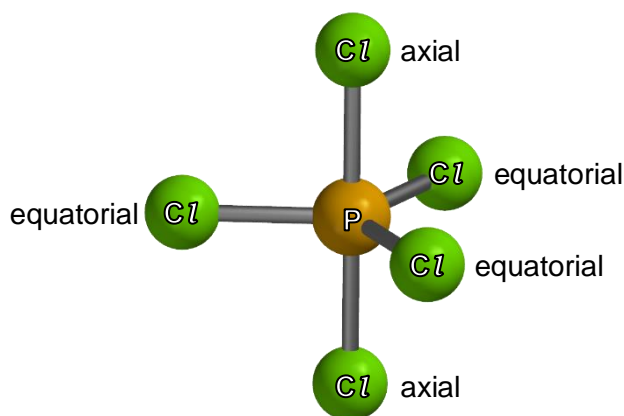


Fig. 6.1

The bond lengths for the axial P–Cl bond and equatorial P–Cl bond is 240 pm and 202 pm respectively.

By considering the molecular shape and principles of VSEPR, account for the difference in bond lengths.

This is because the axial electron pairs are closer to the three equatorial electron pairs at 90° while the equatorial electron pairs has only two axial electron pairs

at 90° and two equatorial electron pairs at 120° spatial arrangement of electron pairs

Since the axial electron pairs experienced greater electronic repulsion, the axial P–Cl bond is longer.

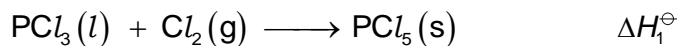
[2]

Comments:

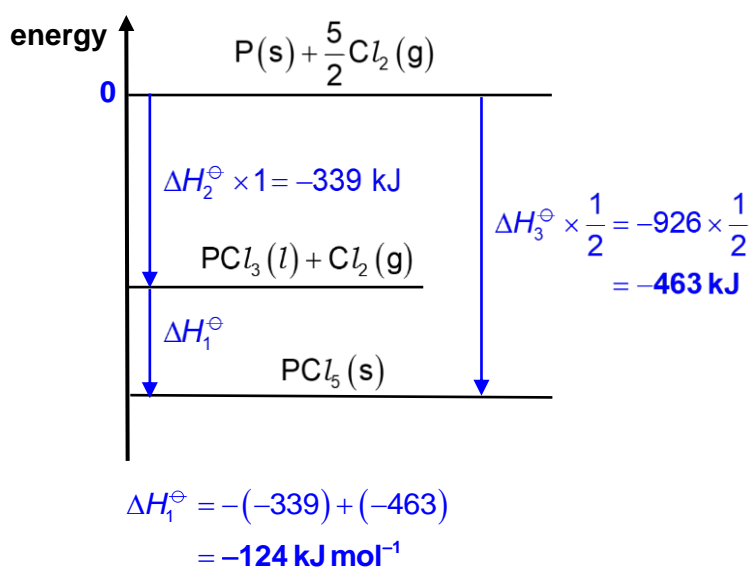
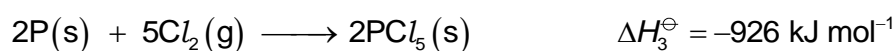
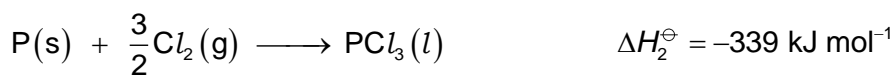
- This part was poorly done in general.

- (b) PCl_5 can be prepared by the chlorination of PCl_3 . This method produces about 10 000 ton of PCl_5 yearly.

For
Examiner's
Use



Determine the standard enthalpy change of chlorination of PCl_5 , ΔH_1^\ominus , by using the information provided and completing the energy level diagram.



Comments:

- This part was well done in general.

[2]

- (c) Samples of $\text{PCl}_5(\text{g})$ often appears yellowish green due to the presence of $\text{Cl}_2(\text{g})$. The standard enthalpy change of decomposition of $\text{PCl}_5(\text{g})$ to $\text{PCl}_3(\text{g})$ is $+87 \text{ kJ mol}^{-1}$.

Comment on the differences in the standard enthalpy change of conversion between PCl_5 and PCl_3 as compared to your answer in (b).

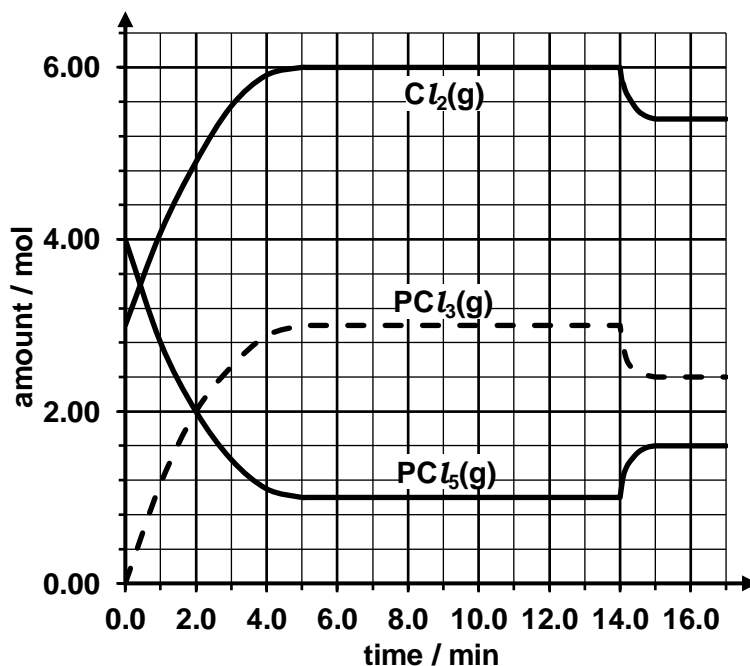
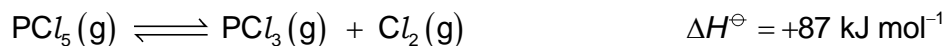
Firstly, the physical states of the PCl_5 and PCl_3 is different in (d) and (e). Energy is taken in to covert the solid/liquid to gaseous state. Hence the magnitude is smaller than 124 kJ mol^{-1}

Secondly, in (d), the exothermic process describes the formation of PCl_5 whereas the decomposition of PCl_5 is the backward reaction. [2]

Comments:

- This part was poorly done in general.
- Many students did not realise the two processes are reversed directions of conversion of PCl_5 to PCl_3 .
- Also there is a difference in physical state of PCl_5 and PCl_3 .

- (d) At 200°C , $\text{PCl}_5(\text{g})$ and $\text{Cl}_2(\text{g})$ were placed in a sealed 2 dm^3 flask and allowed to reached equilibrium. At the 14th minute, a change to the system was introduced.



- (i) Write the equilibrium constant expression, K_c , for the decomposition of $\text{PCl}_5(\text{g})$.

$$K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]}$$

[1]

(ii) Hence calculate the K_c for the decomposition of $\text{PCl}_5(\text{g})$ at 200°C .

$$K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{\left(\frac{3}{2}\right)\left(\frac{6}{2}\right)}{\left(\frac{1}{2}\right)}$$

$$= \underline{9 \text{ mol dm}^{-3}}$$

[2]

Comments:

- This part was well done in general.
- Some students, however, did not convert amount to concentration.

(iii) Deduce, with reasoning, the factor responsible for the new equilibrium established after 14 minutes.

At 14 min, temperature of the flask was decreased.

By Le Chaterlier's Principle, decreasing temperature will favour exothermic

reaction, releasing heat to counteract the change. Also from the graph, $[\text{PCl}_3]$

and $[\text{Cl}_2]$ is lower in the new equilibrium indicating that the backward reaction

is favoured.

[2]

Comments:

- This part was well done in general.
- Some students, however, gave wrong factors e.g volume change, pressure change.

(e) PCl_5 reacts with hydrazine, N_2H_4 , to give a molecular compound **X** with composition by mass:

P, 20.5 % ; N, 9.2%; Cl, 70.3%

(i) Calculate the empirical formula of **X**.

Consider 100 g of **X**,

	P	N	Cl
mass / g	20.5	9.2	70.3
amt / mol	$\frac{20.5}{31.0} = 0.661$	$\frac{9.2}{14.0} = 0.657$	$\frac{70.3}{35.5} = 1.98$
simplest mole ratio	1	1	3

Empirical formula: **PNC l_3**

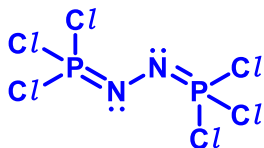
[2]

Comments:

- This part was well done in general.

- (ii) Given that **X** contains an N–N single bond, suggest molecular formula and structure of **X**.

Molecular formula: $\text{P}_2\text{N}_2\text{Cl}_6$

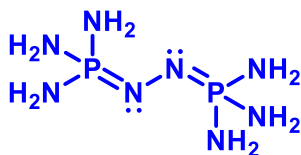


Comments:

- This part was poorly done in general.
- Many students stopped at giving the molecular formula.

[2]

- (iii) Reaction of **X** with ammonia forms compound **Y**, $\text{P}_2\text{H}_{12}\text{N}_8$, and ammonium chloride, NH_4Cl , as the only products. Write an equation for this reaction and suggest a structure for **Y**.



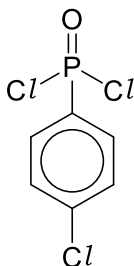
Comments:

- This part was poorly done in general.
- Those who attempted stopped at giving the balanced equation.

[2]

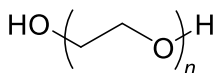
- (f) PCl_3 was used in the synthesis of phosphonate such as that of 4-chlorophenyldichlorophosphonate shown below.

For
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Use



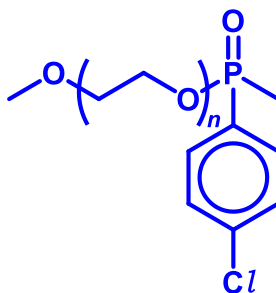
4-chlorophenyldichlorophosphonate

4-Chlorophenyldichlorophosphonate is then reacted with polyethylene glycol (PEG) to form a flame retardant polymer. During the polymerisation reaction, HCl is formed as a side-product.



polyethylene glycol (PEG)

- (i) Draw the one repeating unit of the flame retardant polymer. State the type of polymerisation involved.



Type of polymerisation:..... **Condensation** [2]

Comments:

- The polymer repeating unit was poorly done in general.

- (ii) PEG has low toxicity and can be used as a coating for various surfaces in aqueous and non aqueous environments. Suggest why PEG exhibits such properties, with reference to bonding.

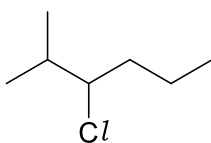
The lone pair of electrons on the O atoms is able to form hydrogen bonds with water while the non-polar alkyl group can form instantaneous dipole-induced dipole interaction. [1]..... [1]

Comments:

- This part was poorly done in general.

[Total: 20]

- 8 (a) The structure of compound **K** is as shown below.

**K**

Compound **K** can react with NaOH under two different conditions to form compound **L** and **M**. **L** is able to exhibit *cis-trans* isomerism and is the monomer from which polymer **N** can be produced. **M** can be oxidised in the presence of hot acidified potassium dichromate to form **P**, $C_7H_{14}O$.

- (i) Suggest the conditions needed to convert **K** to **L** and **M** respectively.

K to **L**: alcoholic/ethanolic, heat

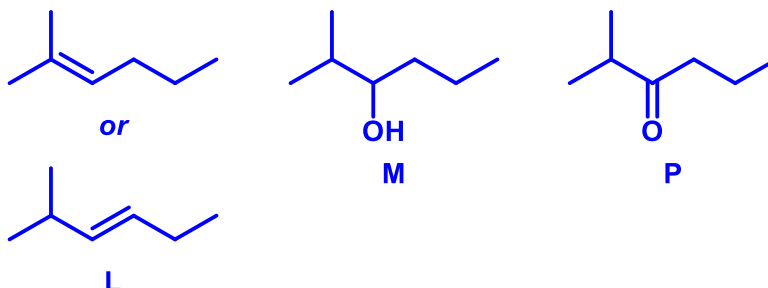
K to **M**: aqueous, heat

[1]

Comments:

- This part was well done in general.

- (ii) Deduce the structures of **L**, **M** and **P**.

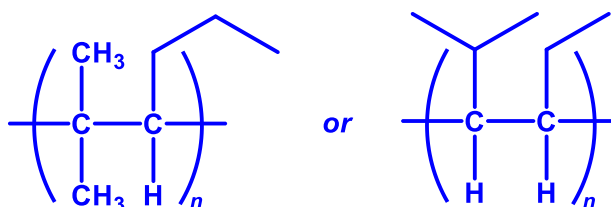


Comments:

- This part was well done in general.

[3]

- (iii) Draw the structural formula of the polymer **N**, showing one repeat unit. State the type of polymerisation involved.

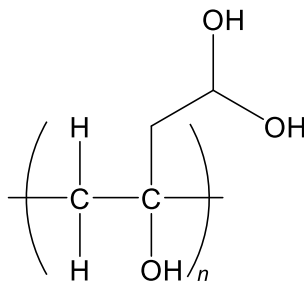


Type of polymerisation: Addition [2]

Comments:

- This part was well done in general.

(iv) The structure of a polymer found in contact lens solution is shown below.



Explain why polymer **N** is unsuitable for this application.

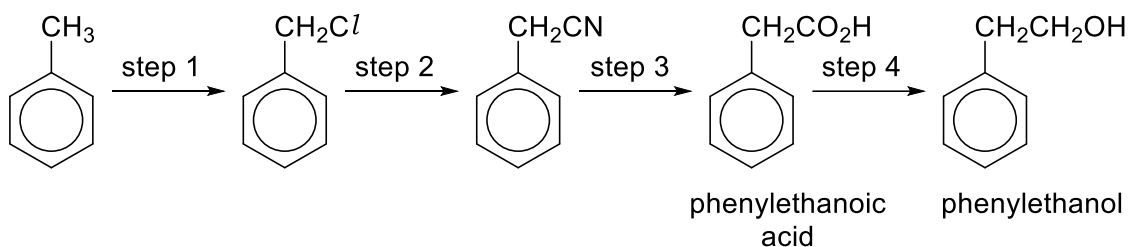
The polymer found in contact lens solution can form hydrogen bonds with water

whilst polymer **N** is unable to form hydrogen bonds with water. [1]

Comments:

- This part was well done in general.

(b) One substance that is responsible for the fragrance of roses is phenylethanol. This can be synthesised from methylbenzene by the following route.



(i) State the reagents and conditions required for Step 1 and 4.

Step 1: (limited) Cl_2 , uv light

Step 4: LiAlH_4 dry ether

[2]

(ii) Suggest the type of reaction in Step 2 and 4.

Step 2: (nucleophilic) substitution

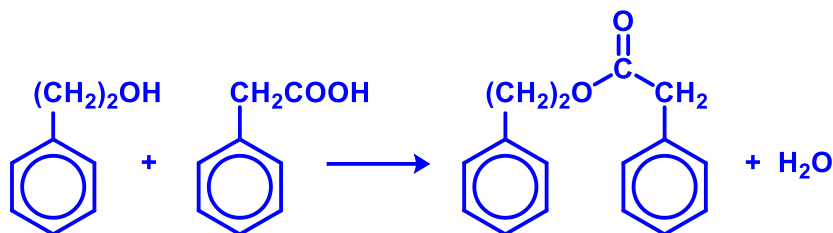
Step 4: reduction

[2]

Comments:

- Part (i) and (ii) was well done in general.

- (iii) Write the balanced chemical equation when phenylethanol reacts with phenylethanoic acid in the presence of hot concentrated sulfuric acid.



[1]

Comments:

- This part was well done in general.

- (iv) Describe a simple one-step test-tube reaction to distinguish between phenylmethanol and phenylethanoic acid.

Reagent and condition: $K_2Cr_2O_7$ (aq), H_2SO_4 (aq), heat OR

$KMnO_4$ (aq), H_2SO_4 (aq) heat

For phenylethanol, $K_2Cr_2O_7$ will turn from orange to green but for phenylethanoic acid, $K_2Cr_2O_7$ will remain orange. OR

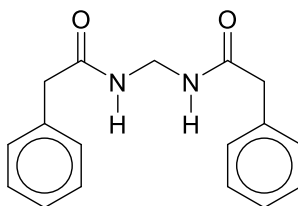
For phenylmethanol, $KMnO_4$ will turn from purple to colourless but for phenylethanoic acid, $KMnO_4$ will remain purple.

[2]

Comments:

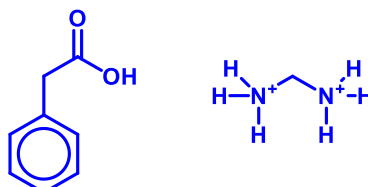
- This part was well done in general.

- (c) In the presence of DCC, phenylethanoic acid reacts with compound X to form the following structure.



- (i) Name the functional group, other than phenyl, in the above compound and draw the products formed when reacted with hot aqueous sulfuric acid.

Functional group: Amide



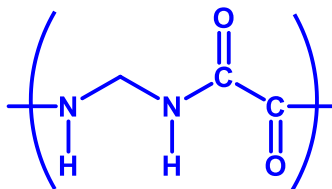
[3]

Comments:

- This part was well done in general except for the structure of compound X. This is an acidic hydrolysis will cause the basic amine product to be neutralised.

- (ii) Compound **X** undergoes condensation polymerisation with ethanedioic acid, $(\text{COOH})_2$, to form polymer **Y**.

Draw a section of polymer **Y** showing one repeat unit.



Comments:

- This part was poorly done in general. Students were unable to draw the correct repeating unit.

[1]

- (iii) Polymer **Y** can be used to make fabric for clothing. State one property that this fabric is likely to possess and one precaution when using this fabric.

Prone to creasing due to the ability of the amide bonds to form hydrogen
bonds with water

It is susceptible to base/acid hydrolysis due to the presence of numerous
amide bonds

[2]

Comments:

- This part was well done in general.

[Total: 20]