Catholic Junior College

JC 2 Preliminary Examinations

Higher 1

CHEMISTRY

8873/01

Paper 1 Multiple Choice

29 August 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

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

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

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

1 Rubidium is a soft, metallic element that has a relative atomic mass of 85.47. There are two forms of naturally occurring rubidium isotopes, ^{85}Rb and ^{87}Rb.
^{87}Rb is slightly radioactive.
What percentage of naturally occurring rubidium is radioactive?

A 11.8 **B** 23.5 **C** 35.3 **D** 76.5

2 10 cm^3 of hydrocarbon was burnt with 100 cm^3 of oxygen gas which is in excess. The resulting mixture was cooled to room temperature and the residual gases occupied a volume of 80 cm^3. After passing through sodium hydroxide, the volume of gas remaining is 40 cm^3.
What is the formula of the hydrocarbon?

A C_3H_6 **B** C_3H_8 **C** C_4H_8 **D** C_4H_{10}

3 Which of the following is true when equimolar amounts of NH_3 and BF_3 is reacted?

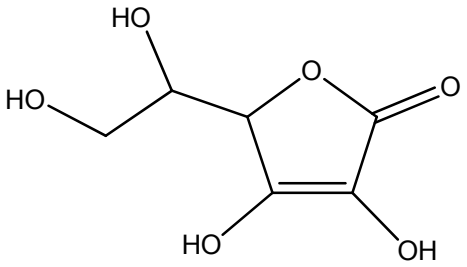
1 a dative covalent bond is formed between NH_3 and BF_3
2 N in NH_3 accepts a lone pair of electrons from B in BF_3
3 the shape around N in NH_3 changes from trigonal planar to tetrahedral
4 after mixing, the bond angle around B in BF_3 decreased from 120^o to 109^o

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

4 *Use of Data Booklet is relevant to this question.*
How many hydrogen atoms are present in 111 g of propanoic acid?
[*L* = Avogadro constant]

A *L* **B** 1.5*L* **C** 7.5*L* **D** 9*L*

5 Ascorbic acid, commonly known as vitamin C, is an important dietary supplement as it is essential in the repairing of tissues and can also function as an antioxidant.



vitamin C

Which of the following shows the correct number of sigma and pi bonds present in one molecule of vitamin C?

	sigma bonds	pi bonds
A	11	2
B	16	2
C	20	1
D	20	2

6 The table below shows the boiling points of some halogenoalkanes.

halogenoalkane	boiling point/^{o}C
CH_3CH_2Cl	12.3
CH_3CH_2Br	34.8
CH_3CH_2I	70.0

Which of the following statements correctly explains the difference in the boiling point?

A the bond energy of C-X bond decreases from C-C*l* to C-I

B the strength of instantaneous dipole-induced dipole attraction increases from CH_3CH_2Cl to CH_3CH_2I

C the strength of permanent dipole-permanent dipole attraction increases from C-C*l* to C-I

D the electronegativity difference between the halogen and carbon increases from C-C*l* to C-I

7 The following information is true for substance **Z**.

- It exists as a solid state at room temperature and pressure
- It has a regular lattice structure at room temperature and pressure
- It does not conduct electricity in both solid and molten state

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

A iodine
B graphene
C aluminium
D sodium chloride

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

Radioactive carbon-14, ^{14}C, is often used to date archaeological and geological samples. Which species has the same number of neutrons and the same number of electrons as an atom of ^{14}C?

A $^{18}Ne^{2+}$ **B** $^{17}F^{+}$ **C** $^{16}O^{2+}$ **D** $^{14}N^{+}$

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

The successive ionisation energies, in kJ mol^{-1}, of an element **X** are given below.

940 2045 3060 4140 6590 7895 14990

What is **X**?

A $_{33}As$ **B** $_{34}Se$ **C** $_{39}Y$ **D** $_{85}At$

10 Element **Y** is in period 3 and has melting point higher than the element before it. **Y** forms a chloride with low melting point which dissolves in water giving a solution of pH 2. What is **Y**?

A magnesium **B** aluminium **C** silicon **D** phosphorus

11 Which of the following statements about Group 17 elements and its compounds are true?

1 Atomic radius increases from chlorine to iodine mainly due to increasing number of electronic shells.
2 Iodine has a higher boiling point compared to chlorine because of stronger instantaneous dipole-induced dipole attraction
3 Hydrogen iodide is less stable to heat than hydrogen chloride due to weaker iodine-iodine bonds.

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

12 Which of the following will have the least exothermic lattice energy?

A barium oxide
B magnesium oxide
C barium sulfide
D magnesium sulfide

13 Hydrazine, N_2H_4, was used as fuel for the Apollo space mission, and it can be synthesised in an environmentally friendly manner according to the following reaction.

$$2NH_3(aq) + H_2O_2(l) \longrightarrow N_2H_4(l) + 2H_2O(l)$$

substance	$\Delta H_f^{\ominus}$ **/ kJ mol^{-1}**
$H_2O(l)$	–286
$N_2H_4(l)$	+51
$NH_3(aq)$	–80
$H_2O_2(l)$	–174

Given the above enthalpy changes of formation, what is the enthalpy change of the above reaction in kJ mol^{-1}?

A −187 **B** −19 **C** +19 **D** +187

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

Methanol (M_r 32) is a preferred fuel for high performance racing cars. When 1.00 g of methanol was burnt to heat up a copper can with 200 g of water, it was found that the temperature of the water rose by 27 °C.

Assuming there is no heat lost to the copper can or surrounding, which value for the enthalpy change of combustion of methanol is given by these results?

A −8026 kJ mol^{-1}
B −722 kJ mol^{-1}
C −251 kJ mol^{-1}
D −113 kJ mol^{-1}

15 Equal amounts of hydrogen and iodine were kept at a constant temperature of 723 K until equilibrium was reached. After which, rapid cooling was conducted to extract the iodine present for titration, and it was found that 0.07 mol of iodine was present.

$$I_2(g) + H_2(g) \rightleftharpoons 2HI(g) \qquad K_c = 48.2 \text{ at } 723 \text{ K}$$

What is the amount in moles of HI at equilibrium?

A 0.236 **B** 0.243 **C** 0.486 **D** 1.84

16 Methanol can be manufactured industrially, using a copper oxide catalyst at temperature of 575 K, according to the following reaction.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91 \text{ kJ mol}^{-1}$$

Which of the following statements are correct?

1 The catalyst increases the equilibrium constant.
2 The catalyst increases the equilibrium yield.
3 At lower temperature the equilibrium yield will increase.
4 At lower temperature the equilibrium constant will increase.

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

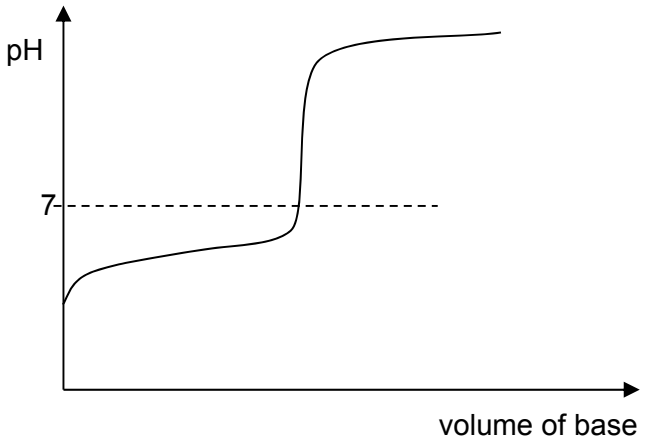
17 The Haber process is a key reaction in the industry for producing ammonia.
Which statement about Haber process is **not** correct?

A Iron is used as a heterogeneous catalyst to increase rate of production.
B Temperature of around 500 °C is used to increase the yield of ammonia.
C High pressure is preferred for this reaction as it increases the yield of ammonia.
D High pressure and temperature leads to an increase in the rate of production.

18 What is the final pH of the solution when equal volumes of 0.030 mol dm^{-3} of $Ba(OH)_2(aq)$ is mixed with 0.030 mol dm^{-3} of HC*l*(aq)?

A 1.5 **B** 1.8 **C** 12.2 **D** 12.5

19 Visual indicators are often used to determine the end point of acid-base titrations. A titration was carried out between a weak acid and a strong base and the titration graph obtained is shown below:



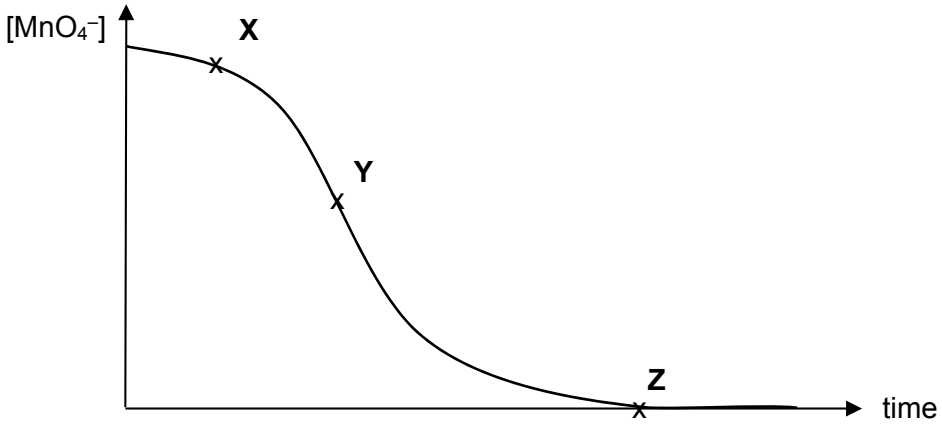
Which of the following is a suitable indicator for the above titration?

	Indicator	pH at which colour changes
A	Methyl violet	0 - 1
B	Bromocresol green	3 - 6
C	Bromothymol blue	6 - 7
D	Thymolphthalein	9 - 11

20 The reaction of manganate(VII), MnO_4^-, with oxalate, $C_2O_4^{2-}$ is a type of autocatalytic reaction whereby the product, manganate(II) ions, is the catalyst for the reaction.

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

The following graph was obtained when $[MnO_4^-]$ was plotted against time.



Which of the following can be deduced from the graph?

A Rate at point **X** is very slow indicating that the temperature is low.
B Rate at point **Y** fast due to the production of the catalyst.
C Rate at point **Z** is slow as the catalyst is saturated.
D Rate at point **Z** is slow as the reaction is zero order with respect to $[MnO_4^-]$.

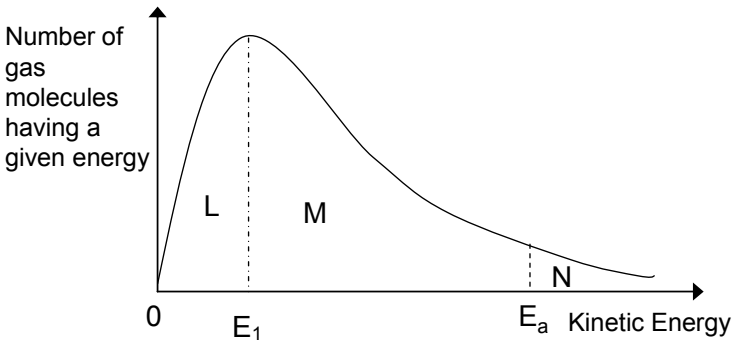
21 When aqueous solutions of HCO_2H and Br_2 are reacted together, initial rate of reaction was found to be 0.080 mol dm^{-3} s^{-1}.
Given that the rate equation is:

$$\text{rate} = k[Br_2][HCO_2H]$$

Which of the following shows the initial rate of reaction when the original reaction mixture was mixed with an equal volume of water?

A 0.010 mol dm^{-3} s^{-1}
B 0.020 mol dm^{-3} s^{-1}
C 0.040 mol dm^{-3} s^{-1}
D 0.080 mol dm^{-3} s^{-1}

22 The Boltzmann distribution at a constant temperature is shown below:
E_1 and E_a are fixed energy values.



If the temperature is decreased by 10 ºC, what happens to the size of the areas labelled **L**, **M** and **N**?

	L	**M**	**N**
A	decreases	decreases	decreases
B	decreases	increases	decreases
C	increases	decreases	decreases
D	increases	decreases	increases

23 The following table gives the approximate dimensions of certain substances.

	substance	**dimensions**
1	Fullerene (buckyball)	Diameter 0.71 nm
2	Red blood cell	Diameter of 8 μm, thickness of 2.5 μm
3	DNA strand	Diameter 2 nm, length up to 5 cm
4	Adenovirus	Diameter 90 nm

(1 μm = 1000 nm)

Which of these would be considered nanoparticles?

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

24 Dishwasher pouches are small convenient packets that contain the detergent needed to be used in dishwashers. Such pouches are sturdy enough to be easily transported and safely handled by hand, yet dissolve easily when it is time to wash dishes. What could be the polymer that is used for the pouches?

A Polyvinyl alcohol
B Polyvinyl chloride
C Poly(diallyl phthalate)
D Poly(ethylene terephthalate)

25 The reaction scheme outlines the production of one of the monomers of nylon 66 from C*l*$(CH_2)_4$Br.

$$Cl(CH_2)_4Br \xrightarrow{\text{step 1}} NC(CH_2)_4CN \xrightarrow{\text{step 2}} H_2N(CH_2)_6NH_2$$

What are the types of reactions for each stage?

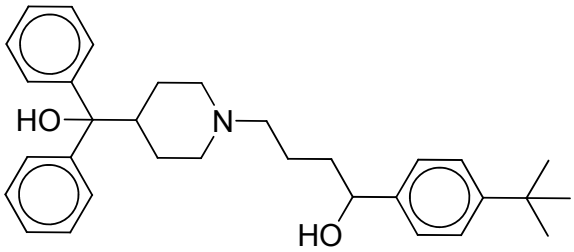
	step 1	**step 2**
A	substitution	oxidation
B	substitution	reduction
C	addition	addition
D	addition	reduction

26 Which of the following are true regarding polyester fabrics in comparison to polyamide fabrics?

1 Polyester fabrics tend to crease less easily than polyamide fabrics.
2 Polyester fabrics tend to be more easily stained by oil than polyamide fabrics.
3 Polyester fabrics tend to absorb more sweat than polyamide fabrics.

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

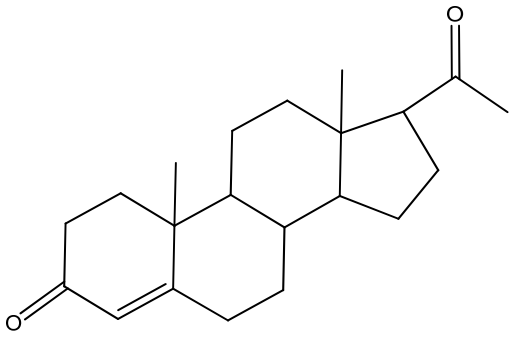
27 *Terfenadine* is an antihistamine formerly used for the treatment of allergic conditions. The structure of *terfenadine* is shown below:



Which functional group is not present in *terfenadine*?

A amine
B tertiary alcohol
C secondary alcohol
D phenol

28 Progesterone is a hormone which is involved in menstrual cycle and pregnancy. The following structure shows one molecule of progesterone.



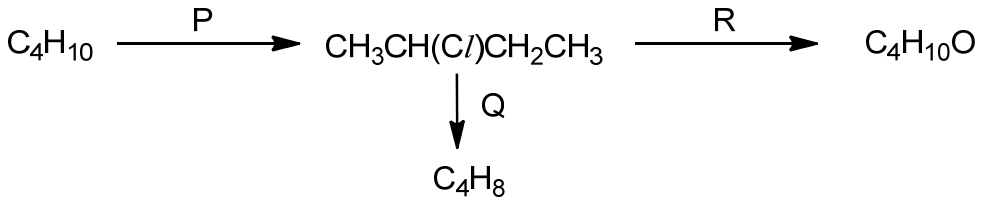
What is the molecular formula for the progesterone hormone?

A $C_{19}H_{14}O_2$ **B** $C_{19}H_{22}O_2$ **C** $C_{20}H_{30}O_2$ **D** $C_{21}H_{30}O_2$

29 Which of the following alcohols can be formed when a ketone is reduced with $NaBH_4$ dissolved in methanol?

A 2-methylpropan-1-ol
B 2-methylbutan-2-ol
C 3-methylbutan-2-ol
D 2,3-dimethylbutan-2-ol

30 The diagram shows a reaction scheme involving 2-chlorobutane, $CH_3CH(Cl)CH_2CH_3$.



Which of the following is true regarding the reaction scheme above?

1 both reactions P and R are substitution reactions
2 reaction Q is a reduction reaction
3 NaOH can be used in both reactions Q and R
4 two constitutional isomers with the molecular formula of C_4H_8 can be formed from reaction Q

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

Catholic Junior College

JC2 Preliminary Examinations

Higher 1

CANDIDATE NAME	
CLASS	**2T**

CHEMISTRY

Structured Questions

8873/02
17 August 2018
2 hours

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all 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.
You are reminded of the need for good English and clear presentation in your answers.

A Data Booklet is provided.

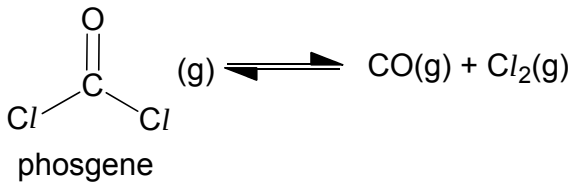
The number of marks is given in brackets [ ] at the end of each question or part of the question.

Section A	**Q1**	/12
	Q2	/6
	Q3	/15
	Q4	/6
	Q5	/6
	Q6	/15
Section B	**Q7**	/20
	Q8	/20
	Paper 2	/80
	Paper 1	/30
	Percentage	
	Grade	

Section A

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

1 (a) Phosgene, $COCl_2$ is a gas with many industrial uses. At high temperature, gaseous phosgene decomposes to carbon dioxide and chlorine in a dynamic equilibrium according to the following equation:



phosgene

(i) Explain what is meant by the term *dynamic equilibrium.*

At dynamic equilibrium, the **rates of the forward and reverse reactions are equal** while there is **no change** in concentration/no. of mole of reactants and products.

(ii) Write an expression for the equilibrium constant, K_c, for the reaction.

Calculate its value when, at equilibrium, the concentrations of $COCl_2$(g), CO(g), and Cl_2(g) are 0.219 mol dm^{-3}, 0.530 mol dm^{-3} and 0.530 mol dm^{-3} respectively.

$K_c = \frac{[CO][Cl_2]}{[COCl_2]}$

$K_c = \frac{(0.530)(0.530)}{(0.219)}$ = 1.28 mol dm^{-3}

[2]

(iii) A certain amount of phosgene was added and the new equilibrium concentration of phosgene is 0.290 mol dm^{-3}. Calculate the new equilibrium concentration of CO(g).

Concentration of CO(g) and Cl_2(g) are equal as seen in part (ii)

$K_c = \frac{[CO]^2}{[COCl_2]} = \frac{[CO]^2}{0.290}$ = 1.28 mol dm^{-3}

new equilibrium concentration of CO(g) = 0.609 mol dm^{-3}

(iv) Calculate the amount in moles of phosgene added in part **(iii)**, given that the volume of the container is 3 dm^3.

	$COCl_2(g)$	⇌	$CO(g)$	+	$Cl_2(g)$
Initial amount / mol	3(0.219) + n = 0.657 + n		3(0.530) = 1.59		3(0.530) = 1.59
Change / mol	– 0.237		+0.237		+0.237
Equilibrium amount / mol	3(0.290) = 0.870		3(0.609) = 1.827		3(0.609) = 1.827

[The ICE table is not necessary. It helps to visualise the changes]

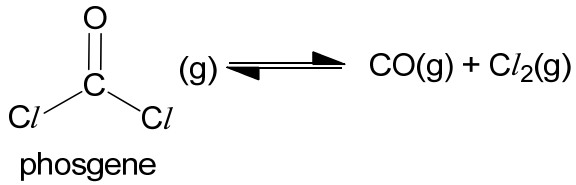
Let the amount added be n.
0.657 + n – 0.237 = 0.870
n = 0.450 mol

[2]

(b) Predict and explain how a decrease in pressure of the system will affect the position of equilibrium.

When the pressure of the system is decreased, the system will react to increase the pressure by increasing the number of moles of gas , thus the position of equilibrium will shift to the right. [2]

(c) **(i)** By using bond energy values from the *Data Booklet,* calculate the enthalpy change for the decomposition of phosgene as shown below:



phosgene

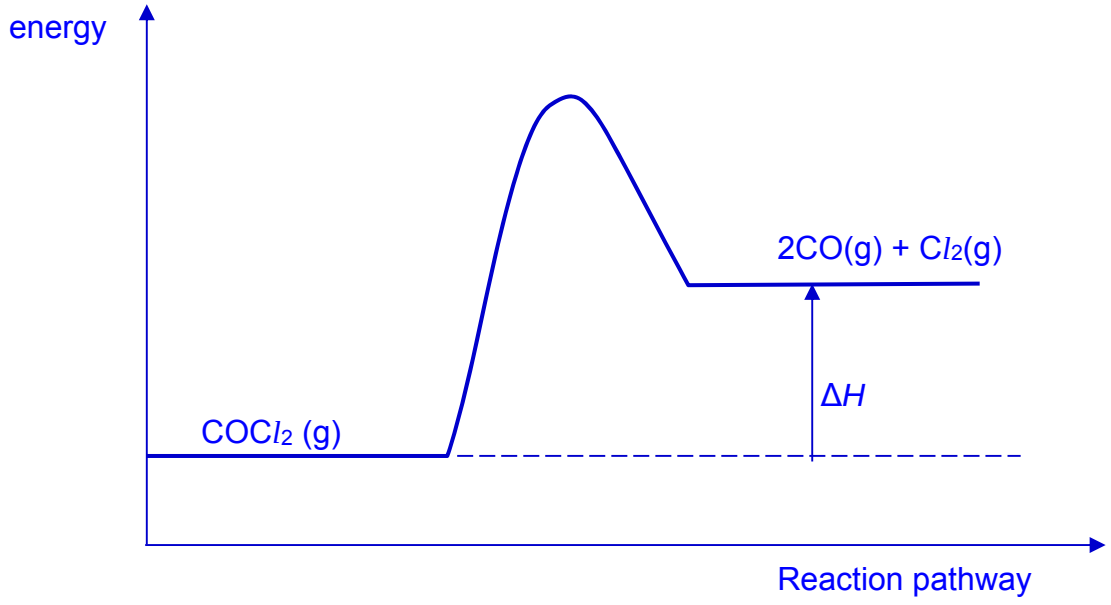
Bonds broken		Bonds formed	
1 C=O	**740**	1 C≡O	1077
2 C-Cl	2(340)	1 Cl-Cl	244

ΔH = (740 + 2 × 340) – (1077 + 244)

= 1420 – 1321 = + 99.0 kJ mol^{-1}

[2]

(ii) Use your answer from part **(i)** to sketch a reaction pathway diagram for the decomposition of phosgene. Draw a labelled arrow to show the enthalpy change on your diagram.



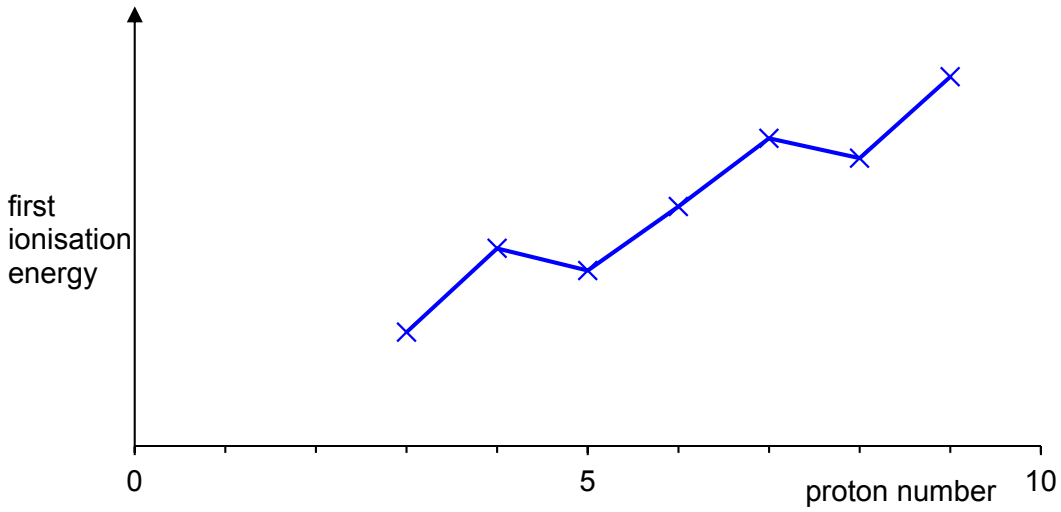
[2]

[Total: 12]

2(a) Write an equation to show the first ionisation energy of oxygen.

$O(g) \rightarrow O^+(g) + e^-$ **[with state symbols]**

(b) Sketch how the first ionisation energies of the elements change from lithium to fluorine.



(c) Explain why the first ionisation energy of oxygen is lower than

- nitrogen

N $1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$

O $1s^2\ 2s^2\ 2p_x^2\ 2p_y^1\ 2p_z^1$

Oxygen has a lower first ionisation energy than nitrogen, as less energy is required to remove an electron from paired $2p_x$ electrons in oxygen since **inter-electron repulsion** is experienced between the paired electrons. [2]

- fluorine

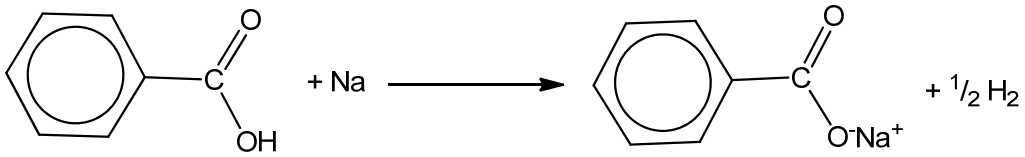
The valence electrons of both oxygen and fluorine atoms experience **similar shielding effect,** but oxygen has **and larger size**, and **smaller nuclear charge** The **attraction** between outermost electrons and nucleus **is lower for oxygen** , resulting in less energy required to remove the outermost electron.

[2]

[Total: 6]

3 Benzoic acid, $C_6H_5CO_2H$, and its salts are often used as food preservatives in fruit juices and other acidic food. They are represented by the E-numbers, E210 to E213 when added as preservatives since they are able to inhibit the growth of mould, yeast and some forms of bacteria.

(a) Sodium metal is added to form the salt of benzoic acid, as shown in the following equation.



benzoic acid sodium benzoate

(i) 5.00 g of sodium metal was added to 0.01 moles of benzoic acid. Calculate the volume of gas produced at standard temperature and pressure for the above reaction.

No. of moles of Na = $\frac{5.00}{23.0}$ = 0.2174

No. of moles of benzoic acid given as 0.01 moles (limiting reagent)

No. of moles of gas formed = 0.01 x 0.5 x **22.7**
=0.114 dm^3 (to 3 s.f)

[2]

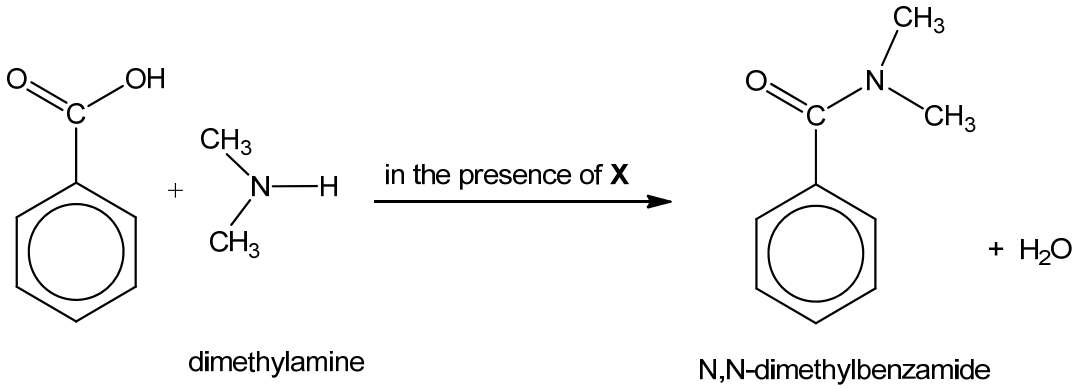
(ii) Explain why sodium benzoate is highly soluble in water but benzoic acid is only partially soluble in water.

Sodium benzoate is able to form ion-dipole interactions with water while the -CO_2H group of the benzoic acid molecule is only able to form hydrogen bonds with water. The phenyl group of the benzoic acid molecule is non-polar and hence is only able to form instantaneous dipole-induced dipole interaction with water.

Hence, more energy is released in the formation of ion-dipole interaction between sodium benzoate and water which is sufficient to overcome the ionic bonds in sodium benzoate and hydrogen bonding between water.

[4]

(b) Benzoic acid can also react with amines to produce amides as shown in the following equation.



dimethylamine

N,N-dimethylbenzamide

(i) Name the type of reaction shown by the above equation.

Condensation reaction

(ii) Identify **X** which is required for the above reaction to occur.

DCC

(iii) State the shape and bond angle around the N atom in dimethylamine.

Shape: Trigonal pyramidal

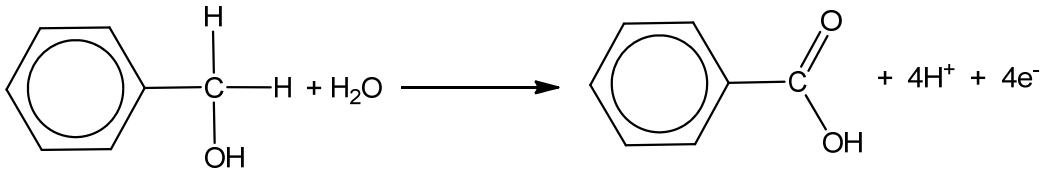
Bond angle: 107° **[accept anything btw 105 ° to 109°]**

(iv) Suggest a reason why the reaction above would **not** occur if dimethylamine is replaced by trimethylamine, $(CH_3)_3N$.

There is no H atom bonded to nitrogen in $(CH_3)_3N$ and a removal of H bonded to nitrogen is required to form H_2O in the amide formation

(c) Benzoic acid can be produced by oxidising phenylmethanol, $C_6H_5CH_2OH$. A suitable oxidising agent for this reaction is hot acidified $KMnO_4$.

The half equation for the oxidation of phenylmethanol is as follows:



phenylmethanol benzoic acid

(i) State the colour change observed when phenylmethanol reacts with hot acidified $KMnO_4$.

Purple $KMnO_4$ decolourises/ turns colourless

(ii) Use the *Data Booklet* and the half equation given above to construct a balanced equation for the oxidation of phenylmethanol by hot acidified $KMnO_4$.

$4MnO_4^- + 5C_6H_5CH_2OH + 12H^+ \rightarrow 4Mn^{2+} + 5C_6H_5CO_2H + 11\ H_2O$

(iii) A pipette was used to transfer 25.0 cm^3 of 0.15 mol dm^{-3} of phenylmethanol into a conical flask. Calculate the minimum volume of 0.20 mol dm^{-3} of acidified $KMnO_4$ required to completely oxidise the phenylmethanol in the conical flask.

No. of moles of $C_6H_5CH_2OH$ = 25/1000 x 0.15 = **3.75×10^{-3}**

From (ii), 4 $KMnO_4$ Ξ 5 $C_6H_5CH_2OH$

No. of moles of $KMnO_4$= 4/5 x 3.75 x 10^{-3}

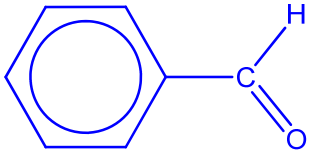
= **0.00300**

Min. vol. of $KMnO_4$= 0.00300 ÷ 0.2

=0.0150 dm^3 or 15.0 cm^3

[2]

(iv) Draw the structure of the product formed when phenylmethanol reacts with acidified $K_2Cr_2O_7$ with immediate distillation (controlled oxidation).



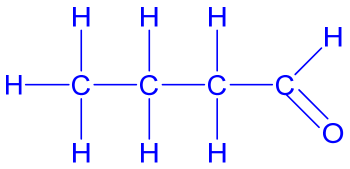
[Total: 15]

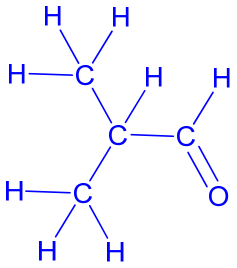
4 Carbon monoxide is a reagent used in an industrial process called hydroformylation. During hydroformylation, high pressure is used and the carbon monoxide reacts with an alkene and hydrogen gas to form an aldehyde.

The equation below shows an example of this process.

$$CO(g) + CH_3CH{=}CH_2(g) + H_2(g) \rightleftharpoons \underset{\text{aldehyde}}{C_4H_8O(g)}$$

(a) In the space below, draw the two possible constitutional isomers of C_4H_8O that are produced in the reaction above.





[2]

(b) The hydroformylation process is important because aldehydes are easily converted into many products. State the type of reaction that has occurred when an aldehyde is converted to a carboxylic acid.

Oxidation

(c) While the hydroformylation process uses rhodium catalyst in its soluble form, elemental rhodium is used in its nanoparticle form as a *heterogeneous catalyst* for other reactants.
Explain the term *heterogeneous catalyst* as fully as you can.
Briefly explain why rhodium in its nanoparticle form works as a better catalyst than in its bulk form.

A catalyst is a substance that increases the rate of reaction by providing an **alternative reaction pathway with a lower energy barrier** (lower Ea) for the reaction to take place.

A heterogeneous catalyst is a catalyst that is in a **different phase** from the reactants.

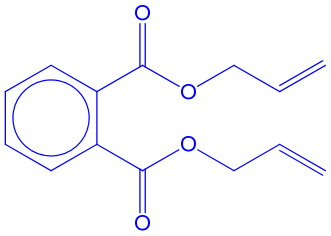
Rhodium in its nanoparticle form has a **large surface area** (or large surface to volume ratio) **for reaction to take place more quickly**.

[3]

[Total: 6]

5 Poly(diallyl phthalate) is an example of a cross linked, thermoset polymer. It is suitable for use in high-performance military electrical components because of its ability to retain its properties when subjected to extreme environmental conditions of high temperature and high humidity.

(a) **(i)** Draw the structure of the monomer of poly(diallyl phthalate) and state the functional group that allows the monomer to become a cross-linked polymer.



Alkene

[2]

(ii) Explain, with reference to its structure and bonding, why it is able to retain its properties under the extreme environmental conditions stated above.

The polymer is **macromolecular with extensive covalent bonds** in the cross links that are **strong and hard to break. Hence the polymer is able to withstand high temperatures**. The polymer is largely **unable to form** extensive **hydrogen bonds with water molecules** and hence it is able to withstand high humidity without degrading.

.....[2]

(b) Calcium alginate is also a cross-linked polymer but its properties vary greatly from poly(diallyl phthalate). Each calcium ion can attach to two alginate polymer strands to form cross-links. Calcium alginate is used in wound dressings. When the dressing needs to be changed, the wound can be rinsed with a solution that will break the cross-links. Suggest a suitable solution that can be used and briefly explain why the cross links are broken.

Sodium chloride solution. **[any group 1 metal salt solution]**

The sodium ions displace the calcium ions. As each **sodium ion is singly charged and unable to attach two polymer strands** , the cross-links begin to fall apart.

.....[2]

[Total: 6]

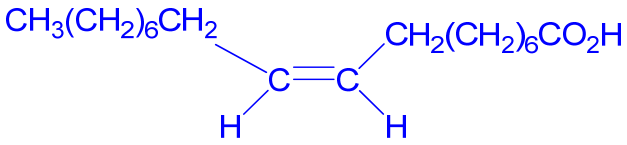
6 Oleic acid is a type of fatty acid that is present in avocados. Oleic acid has the following structure:

$$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$$

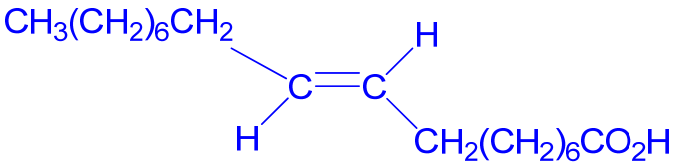
Oleic acid has the cis configuration around the C=C double bond, whereas elaidic acid is the trans isomer of oleic acid.

(a) Draw the condensed structural formulae of oleic acid and elaidic acid, showing clearly the configuration about the C=C in each acid.

oleic acid:



elaidic acid:



[2]

Avocado flesh turns brown rapidly upon exposure to oxygen in the air. In the presence of oxygen, enzymes in the avocado help in the formation of a class of compounds called quinones. Quinones are capable of producing polymers called polyphenols that give the brown colour.

(b)(i) Suggest a simple method that can be done at home to slow down the browning of avocado flesh. Give a brief explanation to support your suggestion.

Wrap it in cling wrap such that a barrier prevents oxygen from reacting with the enzymes. **Or** put the avocado in the fridge as the lowered temperature slows down the browning reaction / inhibits the enzyme from working as quickly. **Or** squeeze lemon / lime juice on the avocado as the lowered pH inhibits the enzyme from working as quickly. **[or any other *logical* suggestion that prevents oxygen from reaching the avocado flesh.] No credit given if the suggestion is correct but the reasoning is wrong.**

(ii) Define the term, *polymer*.

A polymer molecule is a macromolecule made up of monomers, with average molar mass of at least 1000 or at least 100 repeat units.

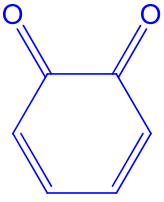
(iii) 1,2-benzoquinone is an example of a quinone. It contains 66.7% carbon and 3.7% hydrogen. The rest of the molecule comprises of oxygen which is present as two ketone functional groups in a molecule of 1,2-benzoquinone.
Calculate the empirical formula of 1,2-benzoquinone. Hence, deduce the molecular formula of 1,2-benzoquinone, stating clearly how you arrived at your answer.

	C	**H**	**O**
%	66.7	3.7	**29.6**
%/A_r	$\frac{66.7}{12.0}$ **=5.56**	$\frac{3.7}{1.0}$ **= 3.70**	$\frac{29.6}{16.0}$ **=1.85**
Simplest ratio	3	2	1

Empirical formula is C_3H_2O
As each ketone functional group contains one oxygen atom and there are two ketone functional groups, the molecular formula is $C_6H_4O_2$. **[with valid explanation]**

[3]

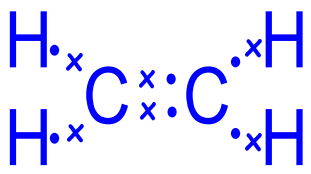
(iv) In a molecule of 1,2-benzoquinone, the two ketone functional groups are on adjacent carbon atoms in a cyclic structure. Using this information and your answer in **(iii)**, draw the skeletal structure of 1,2-benzoquinone.

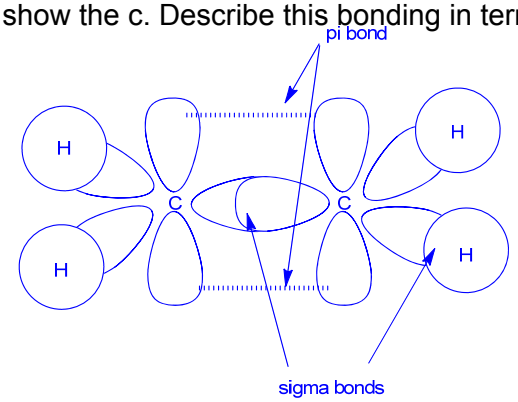


Other structures that are cyclic that satisfy the descriptions are accepted.

Avocados ripen faster if they are put in a plastic bag with some bananas. Bananas produce trace amounts of ethene gas which functions as a ripening hormone in fruits.

(c) Draw a dot-and-cross diagram to show the c. Describe this bonding in terms of orbital overlap.





The drawing is not necessary but clearly a labelled drawing may help in the descriptions.

Ethene has **5 sigma bonds and 1 pi bond**. **[or implied in description]**

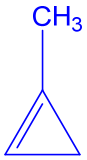
Sigma bonds are formed when an **s orbital of H head-on overlaps** with **an** (sp^2) **orbital of C** and when **an** (sp^2) **orbital of C head-on overlaps with an** (sp^2) **orbital of a neighbouring C.**

[4]

Pi bond is formed when the parallel ***p* orbital** of one C atom, **overlaps side-ways** with the *p* orbital of another C.

Bananas are usually picked from their plantations when they are unripe. But the production of ethene can quickly ripen the fruits during transportation. Hence, to slow down the ripening process, 1-methylcyclopropene is used because it binds tightly to the ethene receptor in the fruits and therefore blocks the effect of ethene.

(d) **(i)** Draw the structure of 1-methylcyclopropene.



(ii) Explain why 1-methylcyclopropene has a higher boiling point than ethene.

Both are simple molecules but **1-methylcyclopropene has more electrons** ….

hence it has **stronger instantaneous dipole – induced dipole forces of** …..

attraction between molecules that need more energy to overcome. ….

[2]

[Total: 15]

Section B

Answer **one** question in the spaces provided.

7(a) Carbonic acid is a weak acid that partially dissociates in water according to the following equation:

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

The K_a of carbonic acid is 4.5×10^{-7} mol dm^{-3}.

The hydrogencarbonate ion, $HCO_3^-(aq)$, can also behave as weak acid in water:

$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$$

The K_a of hydrogencarbonate is 5.0×10^{-11} mol dm^{-3}.

(i) State the relationship between carbonic acid and the hydrogencarbonate ion.

Conjugate acid-base pair / hydrogencarbonate is the conjugate base of carbonic acid, and the difference between the two is only one proton.

(ii) Write the K_a expression for hydrogencarbonate ion and briefly explain why this K_a value is much smaller than the K_a value for carbonic acid.

$$K_a = \frac{[CO_3^{2-}][H_3O^+]}{[HCO_3^-]}$$

It is **more difficult for a positive H^+ to be lost from an negatively charged ion** HCO_3^- due to stronger electrostatic forces of attraction, than from a neutral molecule H_2CO_3. [2]

(iii) The hydrogencarbonate ion is part of the buffer in the blood.
Define *buffer* and explain how $HCO_3^-(aq)$ reacts with acid in the blood. Support your answer with a suitable equation.

A buffer is a solution that maintains a fairly constant pH when small amounts of acid or alkali are added to it.
When blood gets more acidic, the H^+ is removed by HCO_3^-, hence keeping the pH of blood almost constant. $HCO_3^- + H^+ \rightarrow H_2O + CO_2$ [2]

(b) The hydroxyl radical, represented by •OH, is highly reactive and short lived. It is often referred to as the "detergent" of the atmosphere because it reacts with greenhouse gases such as methane.

$$CH_4 + \bullet OH \rightarrow \bullet CH_3 + H_2O$$

A study of the rate of this reaction in a mixture, gave the following results. The initial concentration of methane for this study was much larger than concentration of hydroxyl radical and assumed to be constant throughout the reaction.

Time after start of reaction *t* / x 10^{-4} s	**relative [•OH]**
0.0	10.0
1.0	7.0
2.0	5.0
3.0	3.5
4.0	2.5
5.0	1.8

(i) Define the term *half-life* of a reaction.
Use the data in the table to deduce the half-life of the reaction and to show that the reaction is first order with respect to [•OH].

Half-life is the time taken for the concentration of reactant to fall to half its original value.

The half-life of the reaction is 2.0 x 10^{-4} s.

Time taken for the relative [•OH] to fall from 10.0 to 5.0 and from 5.0 to 2.5 is constant at 2.0 x 10^{-4} s hence the reaction is first order with respect to [•OH].

[3]

(ii) Assume that the order of reaction with respect to $[CH_4]$ is 1, state how the half-life of the reaction would change if:

Initial $[CH_4]$ is doubled:

Half-life will be halved the original value (or half-life will be 1.0 x 10^{-4} s)

Initial relative [•OH] is halved:

Half-life will stay the same (or half-life will still be 2.0 x 10^{-4} s) [2]

(c) Describe reactions that illustrate the variation in acid-base behaviour of the oxides of the elements in Period 3, using MgO, Al_2O_3, and SO_3 as examples.
Write equations for all the reactions you describe.

Across Period 3, the oxides vary **from basic to amphoteric to acidic**.

MgO is a basic oxide which reacts with acid to give salt and water.

$MgO + 2HCl \rightarrow MgCl_2 + H_2O$

Al_2O_3 is an amphoteric oxide which reacts with both acids and alkalis.

$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$

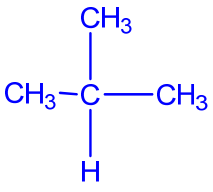
$Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$

SO_3 is an acidic oxide which reacts with alkali to give salt and water.

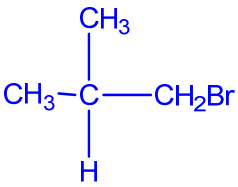
$SO_3 + 2NaOH \rightarrow Na_2SO_4 + H_2O$ [5]

(d) Alkane **A**, C_4H_{10}, reacts with bromine under ultraviolet light to produce only two different mono-brominated products, **B** and **C** in the likely ratio of 9:1. When reacted with alcoholic KOH, both **B** and **C** produce hydrocarbon **D**, C_4H_8.

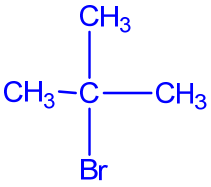
(i) Suggest structures for **A**, **B**, **C** and **D**. Label the structures clearly.



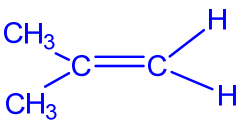
A: C_4H_{10}



B



C



D: C_4H_8

[3]

(ii) Describe a simple chemical test to distinguish between **A** and **D**.

To separate test tubes containing aqueous bromine , bubble gases **A** and **D** into two different test tubes. Orange aqueous bromine decolourises in the presence of **D** but remains orange in the presence of **A**. [2]

OR To separate test tubes containing bromine in CCl_4, bubble gases **A** and **D** into two different test tubes. Reddish-brown bromine decolourises in the presence of **D** but remains reddish-brown in the presence of **A**.

[Total: 20]

8(a) The table below gives the acid dissociation constants, K_a, of three acids at 25 °C.

Acid	Formula	K_a / mol dm^{-3}
Methanoic acid	HCO_2H	1.8×10^{-4}
Ethanoic acid	CH_3CO_2H	1.5×10^{-5}
Chloroethanoic acid	CH_2ClCO_2H	1.3×10^{-3}

(i) From the K_a values, identify the strongest of the three acids and write the K_a expression for the acid you identified.

Chloroethanoic acid

$$K_a = \frac{[CH_2ClCO_2^-][H^+]}{[CH_2ClCO_2H]}$$

[2]

(ii) A student needed to select one of the three acids above to prepare a buffer solution of pH 3.80. The acid chosen has to have a pK_a that is closest to the pH value of the buffer solution.

Define the term *buffer*.
Identify the acid chosen for the preparation of the buffer and briefly explain how the buffer can be prepared (calculation of actual amounts is not required.)

A buffer is a solution that maintains a **fairly constant pH** when **small amounts** of acid or alkali are added to it.

Methanoic acid (pK_a is 3.74).

Add about an equal amount of **sodium methanoate or potassium methanoate to methanoic acid.** [3]

OR

Add **sodium hydroxide to a solution of methanoic acid ensuring that methanoic acid is in excess** (or sodium hydroxide is limiting.)

(b) 2-bromopropane, $CH_3CHBrCH_3$, can be hydrolysed by KOH(aq) to form propan-2-ol. Results of an investigation into the kinetics of this reaction are given below.

Expt number	$[CH_3CHBrCH_3]$ / mol dm^{-3}	[KOH] / mol dm^{-3}	Relative initial rate
1	0.10	0.20	1.00
2	0.60	0.40	6.00
3	0.30	0.20	3.00

(i) Define the term *order of reaction*.
Use the data in the table to deduce the order of reaction with respect to each reagent.

The order of reaction with respect to a given reactant is defined as the power to which the reactant concentration is raised to in the experimentally determined rate equation.

Comparing expts 1 and 3, when [KOH] is constant and $[CH_3CHBrCH_3]$ increases by 3 times, relative initial rate increases by 3 times. Hence reaction is first order with respect to $[CH_3CHBrCH_3]$.

Knowing that the reaction is first order with respect to $[CH_3CHBrCH_3]$, when comparing expts 1 and 2 where $[CH_3CHBrCH_3]$ increases by 6 times, rate increases by 6 times also. This indicates that the increase in [KOH] by 2 times has no impact on the rate. Hence reaction is zero order with respect to [KOH]. [or correct mathematical method]

[3]

(ii) Write an overall rate equation for the reaction between $CH_3CHBrCH_3$ and KOH and state the units of the rate constant.

rate = k $[CH_3CHBrCH_3]$ and units of k is s^{-1} (accept min^{-1}).

[2]

(c) The oxides Na_2O, Al_2O_3, and P_4O_{10} differ considerably in their chemical properties. Describe what happens when separate samples of each oxide are added to water Give equations where appropriate and state clearly why, if no reactions occur.

What is the effect of adding universal indicator to each resulting solution?

$Na_2O + H_2O \rightarrow 2NaOH$,

Na_2O **dissolves readily** in water to form an alkaline solution, which will turn universal indicator **purple/blue**.

Al_2O_3, has **does not dissolve** due to its **high lattice energy**, hence the universal indicator should **remain green.**

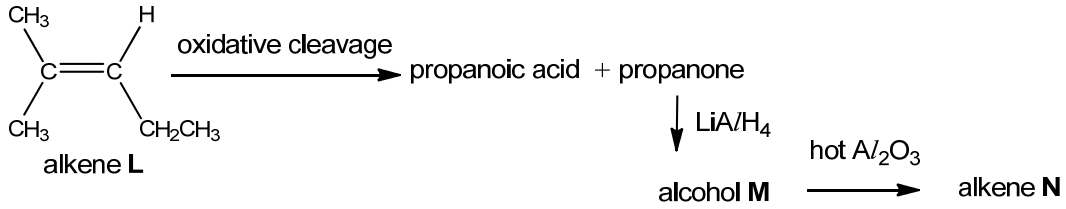
$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$

P_4O_{10} **hydrolyses readily in water** to form an acidic solution, which will turn universal indicator **red/orange**.

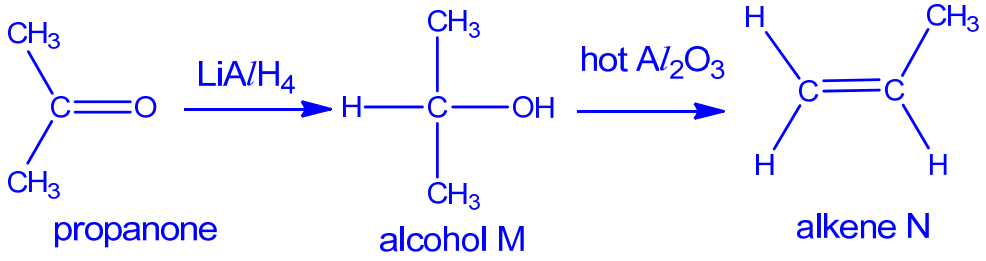
[5]

(d) When reacted with strong oxidising agents under high temperature, alkenes can undergo *oxidative cleavage* reactions. Such reactions involve the complete breaking of the C=C bonds in the alkenes to give carbon-oxygen bonds such as C-O or C=O. These new bonds are part of functional groups such as carboxylic acids and ketones.

Alkene **L** undergoes oxidative cleavage to produce propanoic acid and propanone. Propanone is able to undergo further reactions. The reaction scheme is shown below.



(i) Deduce the structures of **M** and **N**. [2]

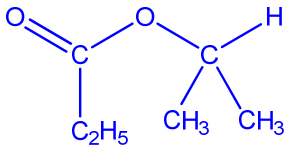


Propanoic acid produced from alkene **L** reacts with alcohol **M** to give a sweet smelling organic compound.

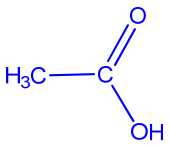
(ii) State the type of reaction that has taken place.

Condensation

(iii) Draw the structure of the organic product produced.



(iv) Draw the structure of the organic product produced when alkene **N** undergoes oxidative cleavage.



[Total: 20]

Catholic Junior College

JC2 Preliminary Examinations

Higher 1

CANDIDATE NAME	
CLASS	**2T**

CHEMISTRY

Structured Questions

8873/02
17 August 2018
2 hours

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all 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.
You are reminded of the need for good English and clear presentation in your answers.

A Data Booklet is provided.

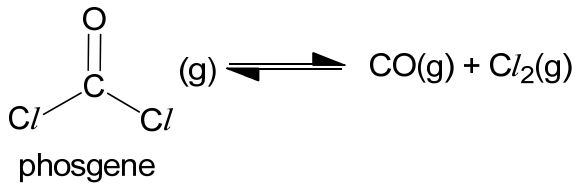
The number of marks is given in brackets [ ] at the end of each question or part of the question.

Section A	**Q1**	**/ 12**
	Q2	**/ 6**
	Q3	**/ 15**
	Q4	**/ 6**
	Q5	**/ 6**
	Q6	**/ 15**
Section B	**Q7**	**/ 20**
	Q8	**/ 20**
	Paper 2	**/ 80**
	Paper 1	**/ 30**
	Percentage	
	Grade	

Section A

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

1 (a) Phosgene, $COCl_2$ is a gas with many industrial uses. At high temperature, gaseous phosgene decomposes to carbon dioxide and chlorine in a dynamic equilibrium according to the following equation:



(i) Explain what is meant by the term *dynamic equilibrium.*

.....

.....

.....[1]

(ii) Write an expression for the equilibrium constant, K_c, for the reaction.

Calculate its value when, at equilibrium, the concentrations of $COCl_2(g)$, $CO(g)$, and $Cl_2(g)$ are 0.219 mol dm^{-3}, 0.530 mol dm^{-3} and 0.530 mol dm^{-3} respectively.

[2]

(iii) A certain amount of phosgene was added and the new equilibrium concentration of phosgene is 0.290 mol dm^{-3}. Calculate the new equilibrium concentration of $CO(g)$.

[1]

(iv) Calculate the amount in moles of phosgene added in part **(iii)**, given that the volume of the container is 3 dm^3.

[2]

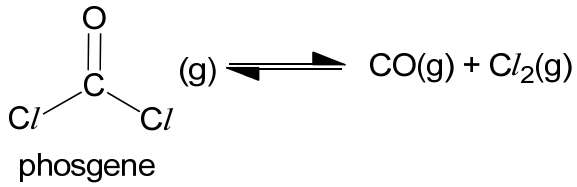
(b) Predict and explain how a decrease in pressure of the system will affect the position of equilibrium.

.....

.....

.....[2]

(c) **(i)** By using bond energy values from the *Data Booklet,* calculate the enthalpy change for the decomposition of phosgene as shown below:



phosgene

[2]

(ii) Use your answer from part **(i)** to sketch a reaction pathway diagram for the decomposition of phosgene. Draw a labelled arrow to show the enthalpy change on your diagram.

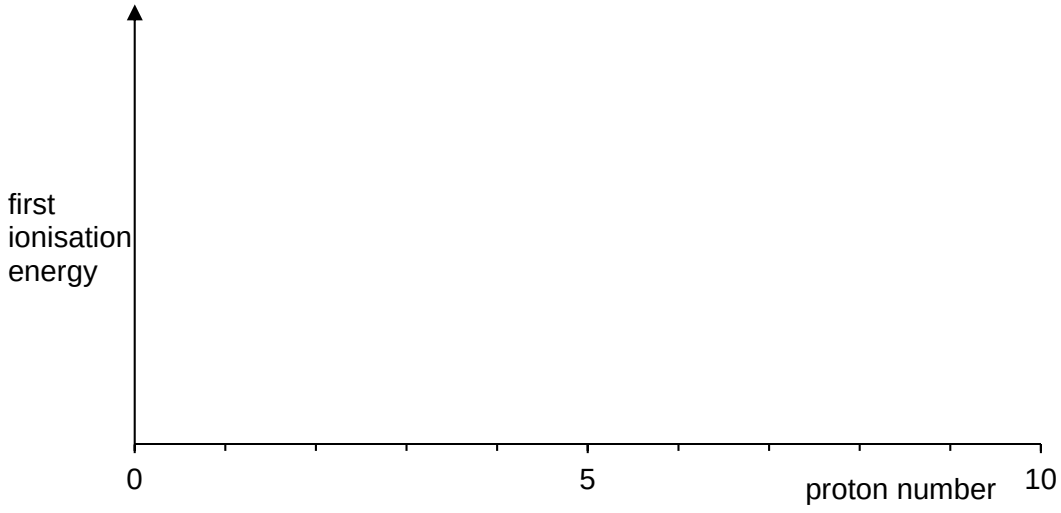
[2]

[Total: 12]

2(a) Write an equation to show the first ionisation energy of oxygen.

……[1]

(b) Sketch how the first ionisation energies of the elements change from lithium to fluorine.



[1]

(c) Explain why the first ionisation energy of oxygen is lower than

- nitrogen

.....

.....

.....

.....

.....[2]

- fluorine

.....

.....

.....

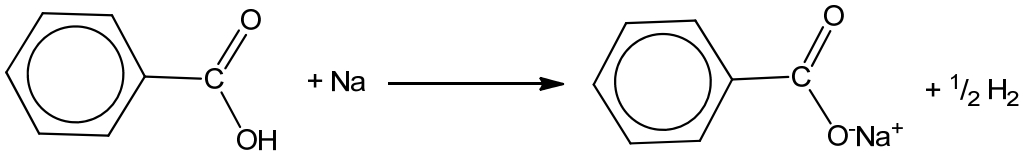
.....

.....[2]

[Total: 6]

3 Benzoic acid, $C_6H_5CO_2H$, and its salts are often used as food preservatives in fruit juices and other acidic food. They are represented by the E-numbers, E210 to E213 when added as preservatives since they are able to inhibit the growth of mould, yeast and some forms of bacteria.

(a) Sodium metal is added to form the salt of benzoic acid, as shown in the following equation.



benzoic acid sodium benzoate

(i) 5.00 g of sodium metal was added to 0.01 moles of benzoic acid. Calculate the volume of gas produced at standard temperature and pressure for the above reaction.

[2]

(ii) Explain why sodium benzoate is highly soluble in water but benzoic acid is only partially soluble in water.

.....

.....

.....

.....

.....

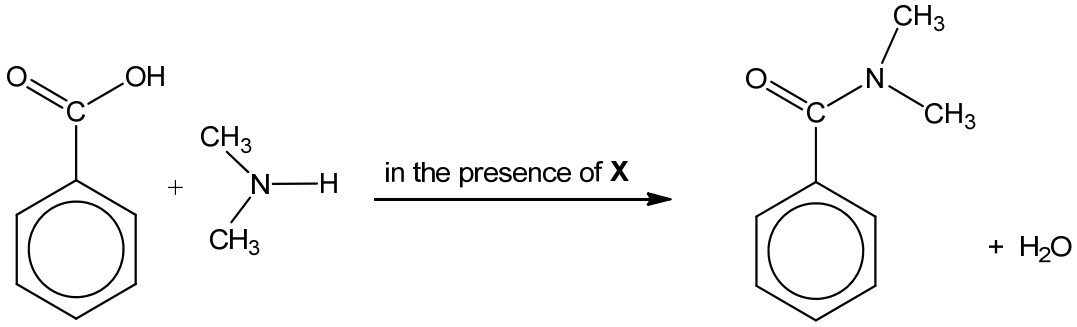
.....

.....

.....

.....[4]

(b) Benzoic acid can also react with amines to produce amides as shown in the following equation.



dimethylamine

N,N-dimethylbenzamide

(i) Name the type of reaction shown by the above equation.

.....[1]

(ii) Identify **X** which is required for the above reaction to occur.

.....[1]

(iii) State the shape and bond angle around the N atom in dimethylamine.

Shape: ……

Bond angle: ……

[1]

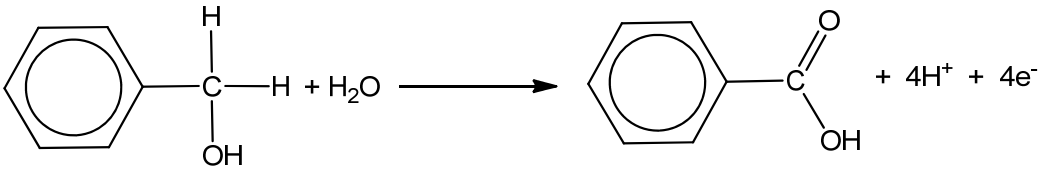
(iv) Suggest a reason why the reaction above would **not** occur if dimethylamine is replaced by trimethylamine, $(CH_3)_3N$.

.....

.....[1]

(c) Benzoic acid can be produced by oxidising phenylmethanol, $C_6H_5CH_2OH$. A suitable oxidising agent for this reaction is hot acidified $KMnO_4$.

The half equation for the oxidation of phenylmethanol is as follows:



phenylmethanol benzoic acid

(i) State the colour change observed when phenylmethanol reacts with hot acidified $KMnO_4$.

.....[1]

(ii) Use the *Data Booklet* and the half equation given above to construct a balanced equation for the oxidation of phenylmethanol by hot acidified $KMnO_4$.

.....[1]

(iii) A pipette was used to transfer 25.0 cm^3 of 0.15 mol dm^{-3} of phenylmethanol into a conical flask. Calculate the minimum volume of 0.20 mol dm^{-3} of acidified $KMnO_4$ required to completely oxidise the phenylmethanol in the conical flask.

[2]

(iv) Draw the structure of the product formed when phenylmethanol reacts with acidified $K_2Cr_2O_7$ with immediate distillation (controlled oxidation).

[1]

[Total: 15]

4 Carbon monoxide is a reagent used in an industrial process called hydroformylation. During hydroformylation, high pressure is used and the carbon monoxide reacts with an alkene and hydrogen gas to form an aldehyde.

The equation below shows an example of this process.

$$CO(g) + CH_3CH{=}CH_2(g) + H_2(g) \rightleftharpoons \underset{\text{aldehyde}}{C_4H_8O(g)}$$

(a) In the space below, draw the two possible constitutional isomers of C_4H_8O that are produced in the reaction above.

[2]

(b) The hydroformylation process is important because aldehydes are easily converted into many products. State the type of reaction that has occurred when an aldehyde is converted to a carboxylic acid.

……[1]

(c) While the hydroformylation process uses rhodium catalyst in its soluble form, elemental rhodium is used in its nanoparticle form as a *heterogeneous catalyst* for other reactants.
Explain the term *heterogeneous catalyst* as fully as you can.
Briefly explain why rhodium in its nanoparticle form works as a better catalyst than in its bulk form.

……

……

……

……

……

……

……

……[3]

[Total: 6]

5 Poly(diallyl phthalate) is an example of a cross linked, thermoset polymer. It is suitable for use in high-performance military electrical components because of its ability to retain its properties when subjected to extreme environmental conditions of high temperature and high humidity.

(a) **(i)** Draw the structure of the monomer of poly(diallyl phthalate) and state the functional group that allows the monomer to become a cross-linked polymer.

[2]

(ii) Explain, with reference to its structure and bonding, why it is able to retain its properties under the extreme environmental conditions stated above.

……

……

……

……

……

……[2]

(b) Calcium alginate is also a cross-linked polymer but its properties vary greatly from poly(diallyl phthalate). Each calcium ion can attach to two alginate polymer strands to form cross-links. Calcium alginate is used in wound dressings. When the dressing needs to be changed, the wound can be rinsed with a solution that will break the cross-links. Suggest a suitable solution that can be used and briefly explain why the cross links are broken.

……

……

……

……[2]

[Total: 6]

6 Oleic acid is a type of fatty acid that is present in avocados. Oleic acid has the following structure:

$$CH_3(CH_2)_7CH=CH(CH_2)_7CO_2H$$

Oleic acid has the cis configuration around the C=C double bond, whereas elaidic acid is the trans isomer of oleic acid.

(a) Draw the condensed structural formulae of oleic acid and elaidic acid, showing clearly the configuration about the C=C in each acid.

oleic acid:

elaidic acid:

[2]

Avocado flesh turns brown rapidly upon exposure to oxygen in the air. In the presence of oxygen, enzymes in the avocado help in the formation of a class of compounds called quinones. Quinones are capable of producing polymers called polyphenols that give the brown colour.

(b)(i) Suggest a simple method that can be done at home to slow down the browning of avocado flesh. Give a brief explanation to support your suggestion.

……

……

……[1]

(ii) Define the term, *polymer*.

……

……[1]

(iii) 1,2-benzoquinone is an example of a quinone. It contains 66.7% carbon and 3.7% hydrogen. The rest of the molecule comprises of oxygen which is present as two ketone functional groups in a molecule of 1,2-benzoquinone.
Calculate the empirical formula of 1,2-benzoquinone. Hence, deduce the molecular formula of 1,2-benzoquinone, stating clearly how you arrived at your answer.

[3]

(iv) In a molecule of 1,2-benzoquinone, the two ketone functional groups are on adjacent carbon atoms in a cyclic structure. Using this information and your answer in **(iii)**, draw the skeletal structure of 1,2-benzoquinone.

[1]

Avocados ripen faster if they are put in a plastic bag with some bananas. Bananas produce trace amounts of ethene gas which functions as a ripening hormone in fruits.

(c) Draw a dot-and-cross diagram to show the bonding in ethene. Describe this bonding in terms of orbital overlap.

[4]

Bananas are usually picked from their plantations when they are unripe. But the production of ethene can quickly ripen the fruits during transportation. Hence, to slow down the ripening process, 1-methylcyclopropene is used because it binds tightly to the ethene receptor in the fruits and therefore blocks the effect of ethene.

(d) **(i)** Draw the structure of 1-methylcyclopropene.

[1]

(ii) Explain why 1-methylcyclopropene has a higher boiling point than ethene.

……

……

……

……

[2]

[Total: 15]

Section B

Answer **one** question in the spaces provided.

7(a) Carbonic acid is a weak acid that partially dissociates in water according to the following equation:

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

The K_a of carbonic acid is 4.5×10^{-7} mol dm^{-3}.

The hydrogencarbonate ion, $HCO_3^-(aq)$, can also behave as weak acid in water:

$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$$

The K_a of hydrogencarbonate is 5.0×10^{-11} mol dm^{-3}.

(i) State the relationship between carbonic acid and the hydrogencarbonate ion.

……

……

…… [1]

(ii) Write the K_a expression for hydrogencarbonate ion and briefly explain why this K_a value is much smaller than the K_a value for carbonic acid.

……

……

…… [2]

(iii) The hydrogencarbonate ion is part of the buffer in the blood.
Define *buffer* and explain how $HCO_3^-(aq)$ reacts with acid in the blood. Support your answer with a suitable equation.

……

……

……

…… [2]

(b) The hydroxyl radical, represented by •OH, is highly reactive and short lived. It is often referred to as the "detergent" of the atmosphere because it reacts with greenhouse gases such as methane.

$$CH_4 + \bullet OH \rightarrow \bullet CH_3 + H_2O$$

A study of the rate of this reaction in a mixture, gave the following results. The initial concentration of methane for this study was much larger than concentration of hydroxyl radical and assumed to be constant throughout the reaction.

Time after start of reaction / x 10^{-4} s	**relative [•OH]**
0.0	10.0
1.0	7.0
2.0	5.0
3.0	3.5
4.0	2.5
5.0	1.8

(i) Define the term *half-life* of a reaction.

Use the data in the table to deduce the half-life of the reaction and to show that the reaction is first order with respect to [•OH].

……

……..

……

……..

……

……..

……[3]

(ii) Assume that the order of reaction with respect to [CH_4] is 1, state how the half-life of the reaction would change if:

Initial [CH_4] is doubled:

……

Initial relative [•OH] is halved:

……[2]

(c) Describe reactions that illustrate the variation in acid-base behaviour of the oxides of the elements in Period 3, using MgO, Al_2O_3, and SO_3 as examples.
Write equations for all the reactions you describe.

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

(d) Alkane **A**, C_4H_{10}, reacts with bromine under UV light to produce only two different mono-brominated products, **B** and **C** in the likely ratio of 9:1. When reacted with alcoholic KOH, both **B** and **C** produce hydrocarbon **D**, C_4H_8.

(i) Suggest structures for **A**, **B**, **C** and **D**. Label the structures clearly.

[3]

(ii) Describe a simple chemical test to distinguish between **A** and **D**.

.....

.....

.....[2]

[Total: 20]

8(a) The table below gives the acid dissociation constants, K_a, of three acids at 25 ^oC.

Acid	Formula	K_a / mol dm^{-3}
Methanoic acid	HCO_2H	1.8×10^{-4}
Ethanoic acid	CH_3CO_2H	1.5×10^{-5}
Chloroethanoic acid	CH_2ClCO_2H	1.3×10^{-3}

(i) From the K_a values, identify the strongest of the three acids and write the K_a expression for the acid you identified.

[2]

(ii) A student needed to select one of the three acids above to prepare a buffer solution of pH 3.80. The acid chosen has to have a pK_a that is closest to the pH value of the buffer solution.

Define the term *buffer*.
Identify the acid chosen for the preparation of the buffer and briefly explain how the buffer can be prepared (calculation of actual amounts is not required.)

……

……

……

……

……

…… [3]

(b) 2-bromopropane, $CH_3CHBrCH_3$, can be hydrolysed by KOH(aq) to form propan-2-ol. Results of an investigation into the kinetics of this reaction are given below.

Expt number	$[CH_3CHBrCH_3]$ / mol dm^{-3}	[KOH] / mol dm^{-3}	Relative initial rate
1	0.10	0.20	1.00
2	0.60	0.40	6.00
3	0.30	0.20	3.00

(i) Define the term *order of reaction*.
Use the data in the table to deduce the order of reaction with respect to each reagent.

……

……..

……

……..

……

……..

……

……..

……

……..

……

……..

……[3]

(ii) Write an overall rate equation for the reaction between $CH_3CHBrCH_3$ and KOH and state the units of the rate constant.

……..

……[2]

(c) The oxides Na_2O, Al_2O_3, and P_4O_{10} differ considerably in their chemical properties. Describe what happens when separate samples of each oxide are added to water Give equations where appropriate and state clearly why if no reactions occur.

What is the effect of adding universal indicator to each resulting solution?

.....

.....

.....

.....

.....

.....

.....

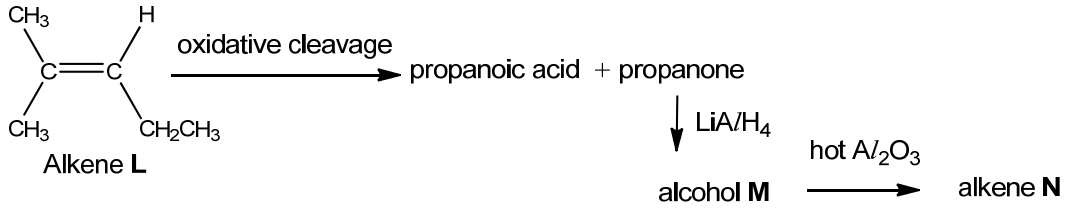
.....

.....

.....[5]

(d) When reacted with a strong oxidising agents under high temperature, alkenes can undergo *oxidative cleavage* reactions. Such reactions involve the complete breaking of the C=C bonds in the alkenes to give carbon-oxygen bonds such as C-O or C=O. These new bonds are part of functional groups such as carboxylic acids and ketones.

Alkene **L** undergoes oxidative cleavage to produce propanoic acid and propanone. Propanone is able to undergo further reactions. The reaction scheme is shown below.



(i) Deduce the structures of **M** and **N**. [2]

Propanoic acid produced from alkene **L** reacts with alcohol **M** to give a sweet smelling organic compound.

(ii) State the type of reaction that has taken place.

.....[1]

(iii) Draw the structure of the organic product produced. [1]

(iv) Draw the structure of the organic product produced when alkene **N** undergoes oxidative cleavage. [1]

[Total: 20]