INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME			
CLASS		INDEX NUMBER	

CHEMISTRY 8873/01

Paper 1 Multiple Choice **14 Sep 2018**

1 hour

Additional Materials: Data Booklet
Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class on all the work you hand in.
Write in soft pencil.
Do not use staples, paper clips, highlighters, 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.

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Any rough working should be done in this booklet.

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

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

1 A giant molecule contains a large amount of carbon, mainly of isotopes ^{12}C and ^{13}C. It was found that the relative atomic mass of carbon in the molecule is 12.20.

What is the ratio of ^{12}C and ^{13}C?

A 3:1 **B** 4:1 **C** 3:4 **D** 1:4

2 Which statements about relative molecular mass are correct?

1 It is the sum of the relative atomic masses of all the atoms within the molecule.

2 It is the ratio of the average mass of a molecule to the mass of a ^{12}C atom.

3 It is the ratio of the mass of 1 mol of molecules to the mass of 1 mol of ^{1}H atoms.

4 It is the ratio of the mass of 1 mol of molecules to the mass of 1 mol of ^{12}C atoms.

A 1 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 4 only

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

Some isotopes are unstable and decompose naturally. In one type of decomposition, a neutron in the nucleus decomposes to form a proton, which is retained in the nucleus, and an electron, which is expelled from the atom.

Which change describes a process of this sort?

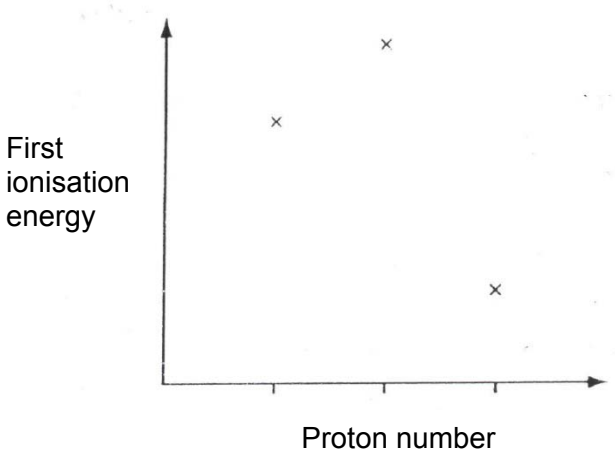
A $^{11}C \longrightarrow {}^{12}C$

B $^{22}Na \longrightarrow {}^{22}Ne$

C $^{32}P \longrightarrow {}^{31}P$

D $^{40}K \longrightarrow {}^{40}Ca$

4 Three successive elements in the Periodic Table have first ionisation energies which have the pattern shown in the diagram.



What could be the first element of this sequence?

A N

B O

C F

D Na

5 Which of the following ions contains half-filled d-orbitals?

1 Mn^{2+}

2 Cu^{+}

3 Fe^{2+}

4 Fe^{3+}

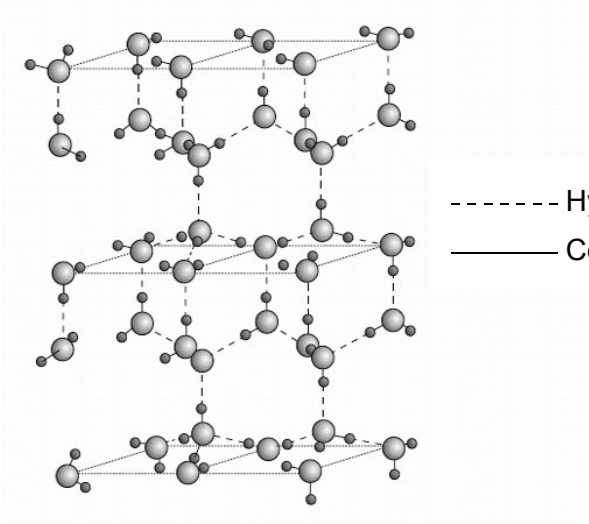
A 1 and 2 only

B 1 and 4 only

C 2 and 3 only

D 3 and 4 only

6 Ice is the crystalline form of water. The diagram below shows part of the structure of ice.



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

A Ice has a lower density than water at 0 °C due to its open structure.

B The bond angle about oxygen in ice is 109.5°.

C Ice does not conduct electricity.

D Ice has a giant covalent structure.

7 Which of the following pairs of substances **does not** include a giant structure and a simple molecular structure?

A aluminum and silicon(IV) oxide

B aluminium oxide and aluminium chloride

C silicon and chlorine

D silicon and silicon(IV) chloride

8 The reaction of ethanal to ethanol using $H_2(g)$ is shown in the equation below.

$$\underset{\text{ethanal}}{CH_3CHO(l)} + H_2(g) \rightarrow \underset{\text{ethanol}}{CH_3CH_2OH(l)}$$

substance	ΔH_c^θ / kJ mol^{-1}
ethanal	–1170
hydrogen	–286
ethanol	–1370

Given the standard enthalpy change of combustion in the table above, what is the enthalpy change of the reduction of ethanal to ethanol?

A +86 kJ mol^{-1} **B** –86 kJ mol^{-1} **C** –2826 kJ mol^{-1} **D** +2826 kJ mol^{-1}

9 The bond dissociation energy of H–F is 565 kJ mol^{-1}. Which equation correctly describes the reaction whereby 565 kJ of energy is released?

A $HF(l) \rightarrow HF(g)$

B $H(g) + F(g) \rightarrow HF(g)$

C $HF(g) \rightarrow H(g) + F(g)$

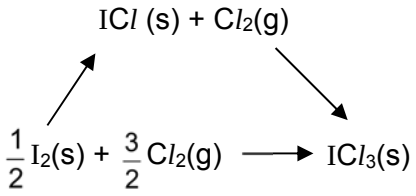
D $\frac{1}{2} H_2(g) + \frac{1}{2} F_2(g) \rightarrow HF(g)$

10 Iodine trichloide, ICl_3, is made by reacting iodine with chlorine.

$$I_2(s) + Cl_2(g) \rightarrow 2ICl(s); \quad \Delta H^{\theta} = + 14 \text{ kJ mol}^{-1}$$

$$ICl(s) + Cl_2(g) \rightarrow ICl_3(s); \quad \Delta H^{\theta} = - 88 \text{ kJ mol}^{-1}$$

By using the above data and the following energy cycle, what is the enthalpy change of the formation of solid iodine trichloride?



A –60 kJ mol^{-1} **B** –74 kJ mol^{-1} **C** –81 kJ mol^{-1} **D** –162 kJ mol^{-1}

11 The decomposition

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

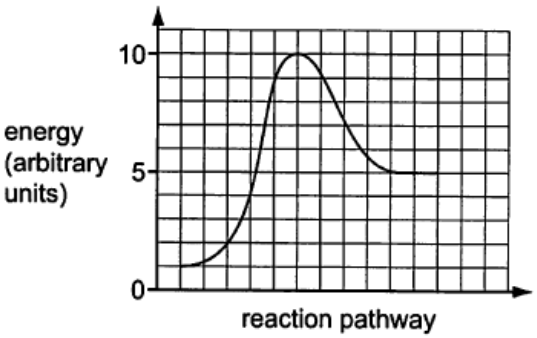
is first order with respect to N_2O_5.

In an experiment 0.10 mol of pure N_2O_5 was put into an evacuated flask. It was found that there was 0.025 mol of N_2O_5 left 34 minutes later.

What is the time taken for the amount of NO_2 to rise from 0 mol to 0.10 mol?

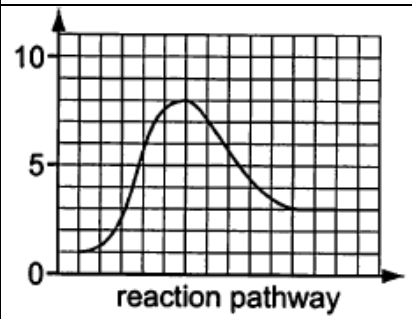
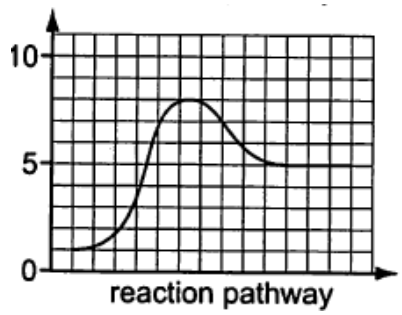
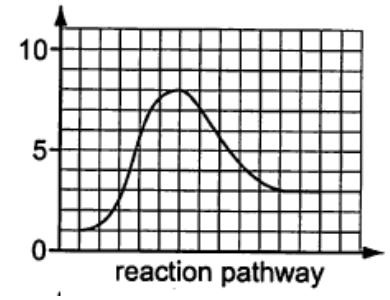
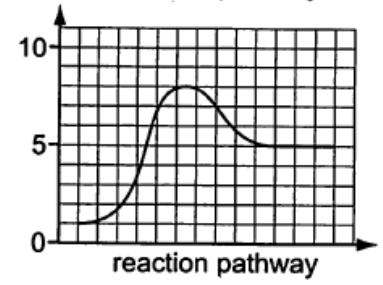
A 17 minutes **B** 34 minutes **C** 68 minutes **D** 136 minutes

12 The diagram shows the reaction pathway diagram for an uncatalysed reaction.



The reaction is then catalysed.

What are the changes in the rate constant and the reaction pathway diagram?

	rate constant	energy profile
A	decrease	
B	decrease	
C	increase	
D	increase	

13 Which one of the following statements about the forward and backward reactions, $P + Q \rightleftharpoons R + S$, is correct when the system is at equilibrium?

A The ratio of the rates of the forward reaction to that of the reverse reaction equals the equilibrium constant.

B The rates of both the forward and the reverse reactions are equal to zero.

C The rates of the forward and reverse reactions are equal.

D The rate constant for the forward reaction equals the rate constant for the reverse reaction.

14 Each of the following equilibria is subjected to two changes carried out separately:

(i) the pressure is reduced at constant temperature;
(ii) the temperature is increased at constant pressure.

For which equilibrium will both of these changes result in an increase in the proportion of products?

A $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$; $\Delta H = +53$ kJ mol^{-1}

B $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$; $\Delta H = -950$ kJ mol^{-1}

C $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta H = -92$ kJ mol^{-1}

D $N_2O_4(g) \rightleftharpoons 2NO_2(g)$; $\Delta H = +57$ kJ mol^{-1}

15 The value of the ionic product of water, K_w, varies with temperature.

Temperature / ^oC	K_w / mol^2 dm^{-6}
25	1.0×10^{-14}
62	1.0×10^{-13}

What can be deduced from this information?

A The ionic dissociation of water is an exothermic process.

B The association of water molecules by hydrogen bonding increases as temperature increases.

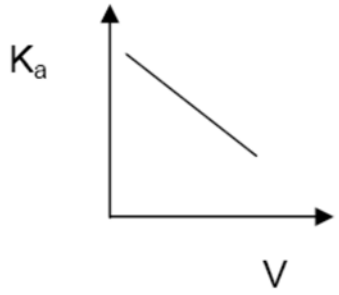
C The pH of pure water increases with temperature.

D At 62 ^{o}C, water with a pH of 6.5 is neutral.

16 1 mol sample of ethanoic acid is diluted at constant temperature to a volume V.

Which diagrams shows how K_a, the acid dissociation constant, varies with V?

A



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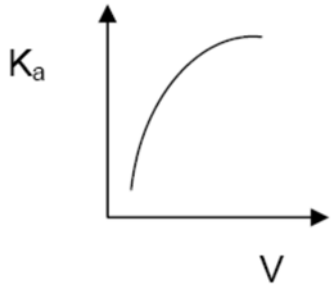

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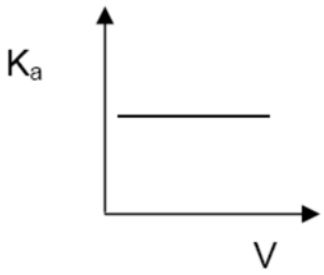

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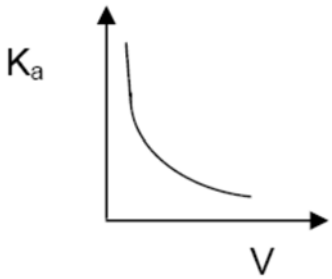


17 The table shows some data on two acid-base indicators.

indicator	approximate pH range	colour change	
		acid	alkali
bromocresol green	3.8 – 5.5	yellow	blue
phenol red	6.8 – 8.5	yellow	red

Which conclusion can be draw about a solution in which bromocresol green is blue and phenol red is yellow?

A It is weakly acidic.

B It is neutral.

C It is weakly alkaline.

D It is strongly alkaline.

18 Which of the following elements forms an insoluble oxide and a chloride which is readily hydrolysed?

A magnesium

B phosphorus

C silicon

D sodium

19 In the preparation of silicon, silicon dioxide is heated with magnesium.

$$SiO_2 + 2Mg \rightarrow 2MgO + Si$$

The product mixture contains MgO and Si only.

To separate the silicon from the product mixture, students proposed the following two possible methods.

1. Shake the mixture with aqueous hydrochloric acid and filter.
2. Heat the mixture gently and collect the evaporated silicon.

Which methods would work?

A 1 and 2 **B** 1 only **C** 2 only **D** neither 1 or 2

20 Which statements concerning the third period elements (sodium to argon) and their compounds are correct?

1 The elements become more electronegative from sodium to chlorine.

2 The melting points of the elements decrease across the period.

3 The maximum oxidation state is shown by silicon.

4 Aluminium oxide is the only oxide which is amphoteric.

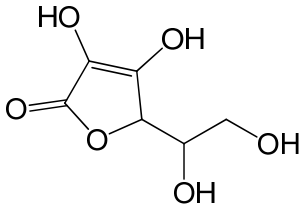
A 1 and 2 only

B 1 and 4 only

C 2 and 3 only

D 3 and 4 only

21 Vitamin C has the following structure.



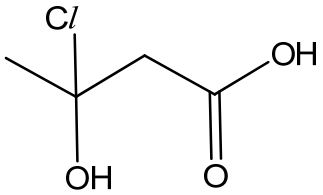
Vitamin C

How many sp^2 and sp^3 hybridised carbon atoms does this molecule have?

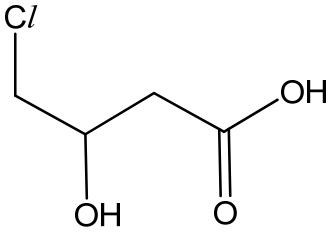
	sp^2	**sp^3**
A	6	0
B	4	2
C	3	3
D	2	4

22 Which structure correctly represents 4-chloro-3-hydroxybutanoic acid?

A



B



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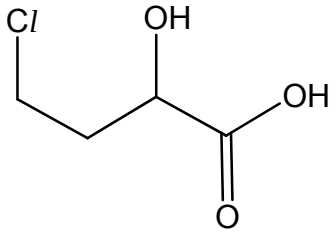

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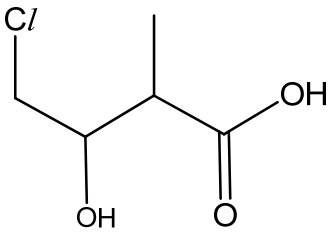


23 As the number of carbon atoms in a homologous series of alkane molecules **increases**, for which property of the alkanes does the numerical value **decrease**?

A density

B enthalpy change of vaporization

C number of isomers

D vapour pressure

24 Compound **E**, C_4H_{10}, reacts with chlorine gas in the presence of light to form two monochlorinated alkanes, **F** and **G**, in an approximate molar ratio of 2 : 3.

What are the structures of **E** and **F**?

	E	**F**
A	$CH_3CH(CH_3)CH_3$	$CH_3CH(CH_3)CH_2Cl$
B	$CH_3CH(CH_3)CH_3$	$CH_3CCl(CH_3)CH_3$
C	$CH_3CH_2CH_2CH_3$	$CH_3CH_2CHClCH_3$
D	$CH_3CH_2CH_2CH_3$	$CH_3CH_2CH_2CH_2Cl$

25 How many different alkenes, including cis-trans isomers, could be produced when 3-methylpentan-2-ol reacts with excess concentrated sulfuric acid at 170 ^oC?

A 2

B 3

C 4

D 5

26 Lactic acid builds up in muscles when oxygen is in short supply. It can cause muscular pain. Part of the reaction sequence is shown.

$$\underset{\text{glyceraldehyde}}{CH_2OHCH(OH)CHO} \rightarrow \underset{\text{pyruvic acid}}{CH_3COCO_2H} \rightarrow \underset{\text{lactic acid}}{CH_3CH(OH)CO_2H}$$

Which statements about the reaction sequence are correct?

1 A secondary alcohol is oxidised to a ketone.

2 A ketone is reduced to a secondary alcohol.

3 An aldehyde is oxidised to a carboxylic acid.

4 A carboxylic acid is reduced to a primary alcohol.

A 1 and 2 only

B 1 and 4 only

C 1, 2 and 3 only

D 2, 3 and 4 only

27 A food chemist wants to create the odour of green apples for a product. An ester with this odour has the formula $CH_3CH_2CO_2CH(CH_3)_2$. In which of the following will the substances react together to produce this ester?

A CH_3CH_2OH and $(CH_3)_2CHCOOH$

B CH_3COOH and $CH_3CH(OH)CH_2CH_3$

C CH_3CH_2COOH and $CH_3CH_2CH_2OH$

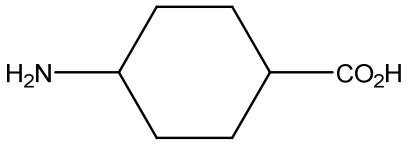
D CH_3CH_2COOH and $(CH_3)_2CHOH$

28 Which compound could be used by itself to form a condensation polymer?

A $HOCH_2CH_2OH$

B $HO_2C(CH_2)_4CO_2H$

C



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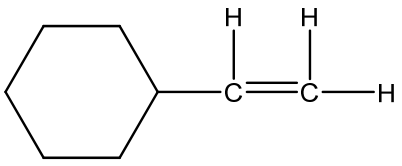
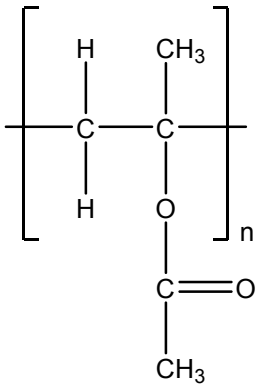
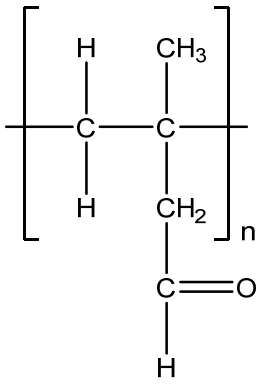


29 The following polymers could be used for contact lenses. Contact lenses have to absorb water so that they can fit comfortably in the eyes. Which polymer will be the most suitable to be used for contact lens?

A



B



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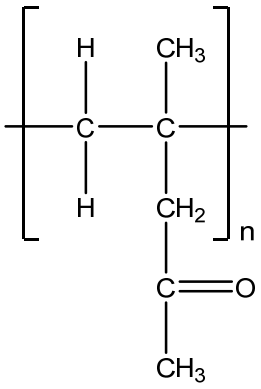

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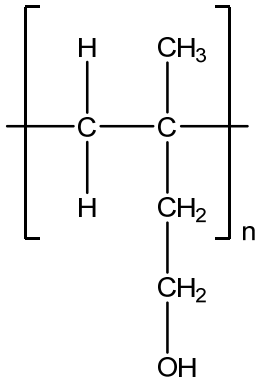

30 Which are the possible ways do nanomaterials enter the human body?

1 skin contact

2 inhalation

3 orally taken

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3 only

End of Paper

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

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

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

1 A giant molecule contains a large amount of carbon, mainly of isotopes ^{12}C and ^{13}C. It was found that the relative atomic mass of carbon in the molecule is 12.20.

What is the ratio of ^{12}C and ^{13}C?

A 3:1 **B** 4:1 **C** 3:4 **D** 1:4

Answer: B

Let the fraction of ^{12}C to be x and the fraction of ^{13}C to be 1-x

$12x + 13(1-x) = 12.2$

$12x + 13 - 13x = 12.2$

$x = 0.8$

$^{12}C : {}^{13}C = 0.8 : 0.2 = 4 : 1$

2 Which statements about relative molecular mass are correct?

1 It is the sum of the relative atomic masses of all the atoms within the molecule.

2 It is the ratio of the average mass of a molecule to the mass of a ^{12}C atom.

3 It is the ratio of the mass of 1 mol of molecules to the mass of 1 mol of ^{1}H atoms.

4 It is the ratio of the mass of 1 mol of molecules to the mass of 1 mol of ^{12}C atoms.

A 1 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 4 only

Answer: A

Option 2 is wrong. It is the ratio of the average mass of a molecule to 1/12 of the mass of a ^{12}C atom.

Option 3 and 4 are wrong. It is the ratio of the mass of 1 mol of molecules to the mass of 1/12 of 1 mol of ^{12}C atoms.

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

Some isotopes are unstable and decompose naturally. In one type of decomposition, a neutron in the nucleus decomposes to form a proton, which is retained in the nucleus, and an electron, which is expelled from the atom.

Which change describes a process of this sort?

A $^{11}C \longrightarrow {}^{12}C$

B $^{22}Na \longrightarrow {}^{22}Ne$

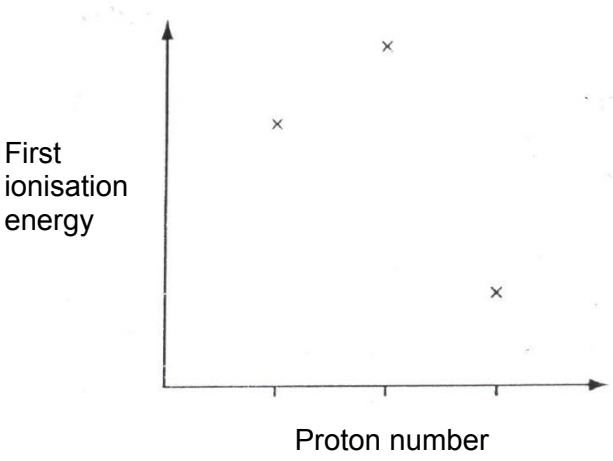
C $^{32}P \longrightarrow {}^{31}P$

D $^{40}K \longrightarrow {}^{40}Ca$

Answer: D

When a neutron in the nucleus decomposes to form a proton, mass number remains the same but proton number increases by 1.

4 Three successive elements in the Periodic Table have first ionisation energies which have the pattern shown in the diagram.



What could be the first element of this sequence?

A N

B O

C F

D Na

Answer: C

Option A is wrong. If N is the first element, the second element will be O. However, there is a decrease in first I.E. between N and O element as there is a pair of electrons in the same p orbital in O which experience inter-electronic repulsion.

Option B is wrong. If O is the first element, the second and third element is F and He which first I.E. increases from O to F to Ne.

Option D is wrong. If Na is the first element, the second element is Mg and Al. There is a slight decrease in I.E. between Mg and Al which is not as shown by the diagram above (large decrease in first I.E. between second and third element.

5 Which of the following ions contains half-filled d-orbitals?

1 Mn^{2+}

2 Cu^{+}

3 Fe^{2+}

4 Fe^{3+}

A 1 and 2 only

B 1 and 4 only

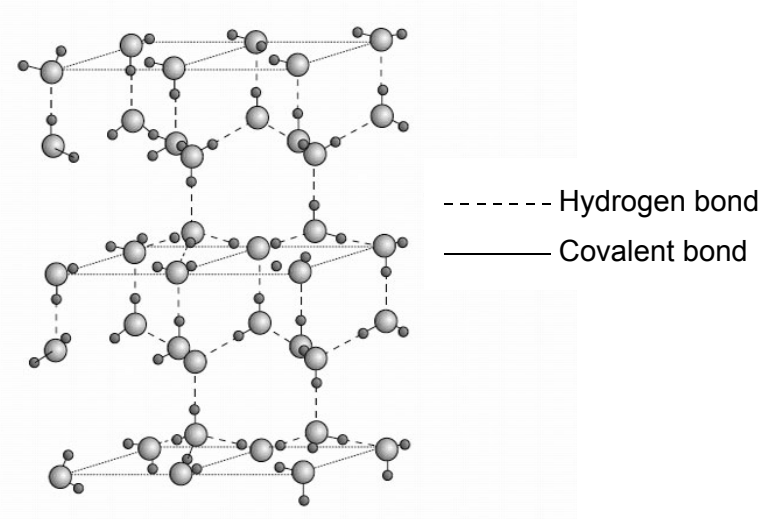
C 2 and 3 only

D 3 and 4 only

Answer: B

The valence electronic configuration of the following ions:
Mn^{2+}: $3d^5$
Cu^{+}: $3d^{10}$
Fe^{2+}: $3d^6$
Fe^{3+}: $3d^5$

6 Ice is the crystalline form of water. The diagram below shows part of the structure of ice.



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

A Ice has a lower density than water at 0 °C due to its open structure.

B The bond angle about oxygen in ice is 109.5°.

C Ice does not conduct electricity.

D Ice has a giant covalent structure.

Answer: D

Ice has simple molecular structure.

7 Which of the following pairs of substances **does not** include a giant structure and a simple molecular structure?

A aluminum and silicon(IV) oxide

B aluminium oxide and aluminium chloride

C silicon and chlorine

D silicon and silicon(IV) chloride

Answer: A

Al_2O_3 has giant ionic structure and SiO_2 has giant covalent structure.
Al_2O_3 has giant ionic structure and $AlCl_3$ has simple molecular structure.
Si has giant covalent structure and Cl_2 has simple molecular structure.
Si has giant covalent structure and $SiCl_4$ has simple molecular structure.

8 The reduction of ethanal to ethanol using $H_2(g)$ is shown in the equation below.

$$\underset{\text{ethanal}}{CH_3CHO(l)} + H_2(g) \rightarrow \underset{\text{ethanol}}{CH_3CH_2OH(l)}$$

substance	ΔH_c^θ / kJ mol^{-1}
ethanal	–1170
hydrogen	–286
ethanol	–1370

Given the standard enthalpy change of combustion in the table above, what is the enthalpy change of the reduction of ethanal to ethanol?

A +86 kJ mol^{-1} **B** –86 kJ mol^{-1} **C** –2826 kJ mol^{-1} **D** +2826 kJ mol^{-1}

Answer: B

$\Delta H_r^\theta = \sum n\Delta H_c^\theta$ (reactants) $- \sum m\Delta H_c^\theta$ (products)
= [–1170+(–286)]– (–1370) = –86 kJ mol^{-1}

9 The bond dissociation energy of H–F is 565 kJ mol^{-1}. Which equation correctly describes the reaction whereby 565 kJ of energy is released?

A $HF(l) \rightarrow HF(g)$

B $H(g) + F(g) \rightarrow HF(g)$

C $HF(g) \rightarrow H(g) + F(g)$

D $\frac{1}{2} H_2(g) + \frac{1}{2} F_2(g) \rightarrow HF(g)$

Answer: B

Bond dissociation energy: $HF(g) \rightarrow H(g) + F(g)$ +565 kJ mol^{-1}

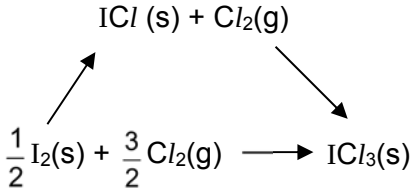
The reverse of the above reaction results in 565 kJ of energy is released.

10 Iodine trichloide, ICl_3, is made by reacting iodine with chlorine.

$$I_2(s) + Cl_2(g) \rightarrow 2ICl(s); \quad \Delta H^{\theta} = +14 \text{ kJ mol}^{-1}$$

$$ICl(s) + Cl_2(g) \rightarrow ICl_3(s); \quad \Delta H^{\theta} = -88 \text{ kJ mol}^{-1}$$

By using the above data and the following energy cycle, what is the enthalpy change of the formation of solid iodine trichloride?



A –60 kJ mol^{-1} **B** –74 kJ mol^{-1} **C** –81 kJ mol^{-1} **D** –162 kJ mol^{-1}

Answer: C

ΔH = +14/2 + (-88) = – 81 kJ mol^{-1}

11 The decomposition

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

is first order with respect to N_2O_5.

In an experiment 0.10 mol of pure N_2O_5 was put into an evacuated flask. It was found that there was 0.025 mol of N_2O_5 left 34 minutes later.

What is the time taken for the amount of NO_2 to rise from 0 mol to 0.10 mol?

A 17 minutes **B** 34 minutes **C** 68 minutes **D** 136 minutes

Answer: A

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

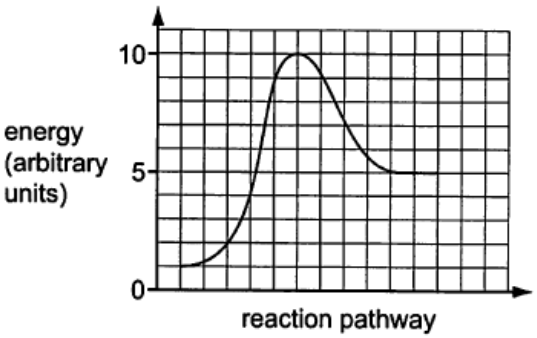
$N_2O_5 : NO_2 = 1 : 2$

For N_2O_5, 0.10 → 0.05 → 0.025 →0.0125 → 0.00625

For NO_2, 0 → 0.10 → 0.15 → 0.175 → 0.1875

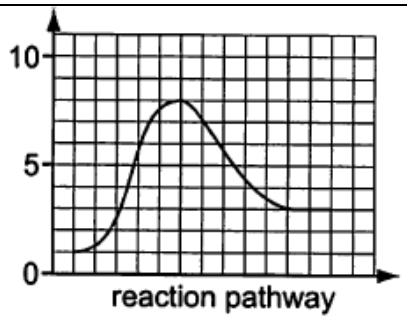
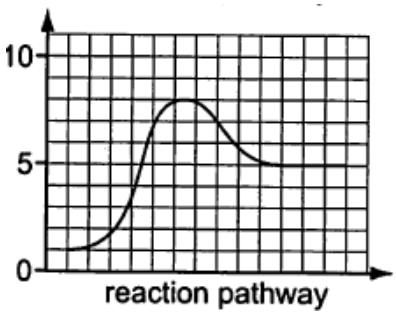
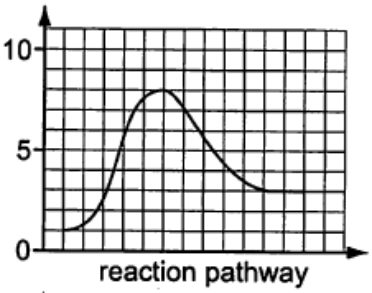
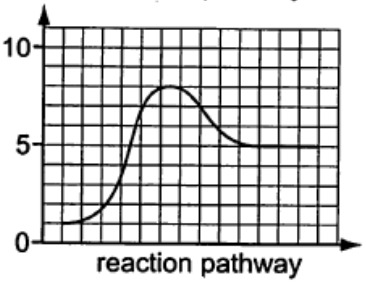
Every 1 → represents one half life (17 mins).

12 The diagram shows the reaction pathway diagram for an uncatalysed reaction.



The reaction is then catalysed.

What are the changes in the rate constant and the reaction pathway diagram?

	rate constant	energy profile
A	decrease	
B	decrease	
C	increase	
D	increase	

Answer: D

When catalyst is added, alternative pathway with lower activation energy is available. This also results in larger rate constant k. The enthalpy change of reaction remains the same.

13 Which one of the following statements about the forward and backward reactions, $P + Q \rightleftharpoons R + S$, is correct when the system is at equilibrium?

A The ratio of the rates of the forward reaction to that of the reverse reaction equals the equilibrium constant.

B The rates of both the forward and the reverse reactions are equal to zero.

C The rates of the forward and reverse reactions are equal.

D The rate constant for the forward reaction equals the rate constant for the reverse reaction.

Answer: C

Option A is wrong. The ratio of the forward rate constant to that of the reverse rate constant equals the equilibrium constant.

Option B is wrong. The rates of both the forward and the reverse reactions are equal (but not = 0).

Option D is wrong. The rate for the forward reaction equals the rate of the reverse reaction.

14 Each of the following equilibria is subjected to two changes carried out separately:

(i) the pressure is reduced at constant temperature;
(ii) the temperature is increased at constant pressure.

For which equilibrium will both of these changes result in an increase in the proportion of products?

A $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$; $\Delta H = +53$ kJ mol^{-1}

B $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$; $\Delta H = -950$ kJ mol^{-1}

C $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta H = -92$ kJ mol^{-1}

D $N_2O_4(g) \rightleftharpoons 2NO_2(g)$; $\Delta H = +57$ kJ mol^{-1}

Answer: D

When pressure is reduced, by Le Chatelier's Principle, the equilibrium position shifts to the side that have more gaseous molecules to increase the pressure. To increase the the proportion of products when pressure is reduced, the products must have more gaseous molecules than reactants. Only Option B and D satisfy this.

When temperature is increased, by Le Chatelier's Principle, the equilibrium position shifts to the side that favors endothermic reaction to decrease tempearture. To increase the the proportion of products when temperature is increased, the forward reaction must be endothermic. Hence, Option D is answer.

15 The value of the ionic product of water, K_w, varies with temperature.

Temperature / ^oC	K_w / $mol^2\ dm^{-6}$
25	1.0×10^{-14}
62	1.0×10^{-13}

What can be deduced from this information?

A The ionic dissociation of water is an exothermic process.

B The association of water molecules by hydrogen bonding increases as temperature increases.

C The pH of pure water increases with temperature.

D At 62 ^oC, water with a pH of 6.5 is neutral.

Answer: D

Option A is wrong as ionic dissociation of water involves bond breaking of water molecules, this is an endothermic reaction.

Option B is wrong. As temperature increases, more hydrogen bonds between molecules are broken.

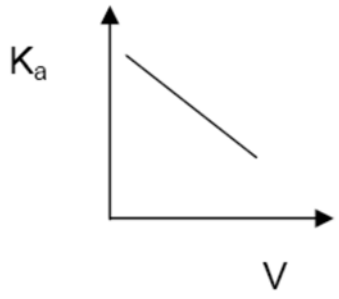
Option C is wrong. The pH of pure water decreases with temperature. (pH = 7 at 25 ^oC and pH = 6.5 at 62 ^oC)

Option D is correct as water is neutral at all temperature as $[H^+] = [OH^-]$.

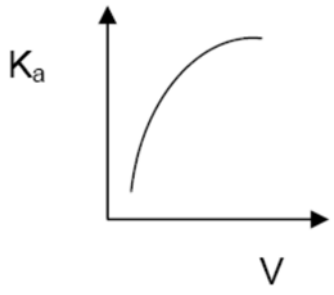
16 1 mol sample of ethanoic acid is diluted at constant temperature to a volume V.

Which diagrams shows how K_a, the acid dissociation constant, varies with V?

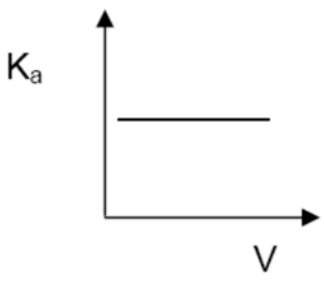
A



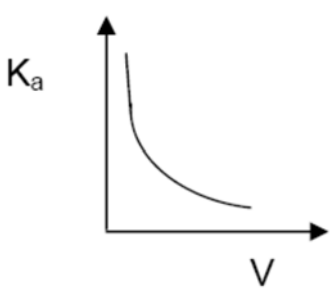
C



B



D



Answer: B Ka is temperature dependent only. (independent of volume of solution)

17 The table shows some data on two acid-base indicators.

indicator	approximate pH range	colour change	
		acid	alkali
bromocresol green	3.8 – 5.5	yellow	blue
phenol red	6.8 – 8.5	yellow	red

Which conclusion can be draw about a solution in which bromocresol green is blue and phenol red is yellow?

A It is weakly acidic.

B It is neutral.

C It is weakly alkaline.

D It is strongly alkaline.

Answer: A

When bromocresol green is added into the solution, the blue colour indicates that the pH of the solution is more than 5.5.

When phenol red is added into the solution, the yellow colour indicates that the pH of the solution is less than 6.8.

For a solution to have pH that is more than 5.5 and less than 6.8, the solution is weakly acidic.

18 Which of the following elements forms an insoluble oxide and a chloride which is readily hydrolysed?

A magnesium

B phosphorus

C silicon

D sodium

Answer: C

Option A is wrong. Magnesium oxide is slighly soluble in water and magnesium chloride undergoes hydration and partial hydrolysis.

Option B is wrong. Phosphorus pentoxide and phosphorus chloride is readily hydrolysed to form an acidic solution.

Option C is correct. Silicon dioxide is insoluble in water due to its giant covalent structure. Silicon tetrachloride is hydrolysed readily to form SiO_2 and HCl.

Option D is wrong. Sodium oxide reacts with water to form sodium hydroxide. Sodium chloride dissolves in water readily but does not undergo hydrolysis.

19 In the preparation of silicon, silicon dioxide is heated with magnesium.

$$SiO_2 + 2Mg \rightarrow 2MgO + Si$$

The product mixture contains MgO and Si only.

To separate the silicon from the product mixture, students proposed the following two possible methods.

1. Shake the mixture with aqueous hydrochloric acid and filter.
2. Heat the mixture gently and collect the evaporated silicon.

Which methods would work?

A 1 and 2 **B** 1 only **C** 2 only **D** neither 1 or 2

Answer: B

Option 1 is correct as MgO is a basic oxide that can react with HCl to undergo acid-base reaction to form salt and water. Si does not react with HCl(aq) due to its giant covalent structure.
$MgO + 2HCl \rightarrow MgCl_2 + H_2O$

Option 2 is wrong. It's almost impposible to collect evaporated silicon as it has extremely high boiling point.

20 Which statements concerning the third period elements (sodium to argon) and their compounds are correct?

1 The elements become more electronegative from sodium to chlorine.

2 The melting points of the elements decrease across the period.

3 The maximum oxidation state is shown by silicon.

4 Aluminium oxide is the only oxide which is amphoteric.

A 1 and 2 only

B 1 and 4 only

C 2 and 3 only

D 3 and 4 only

Answer: B

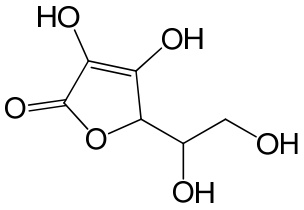
Option 1 is correct. Moving across period, nuclear charge increase, shielding effect remains relatively constant, effective nuclear charge increase. Valence electrons are more strongly attracted and electronegativity increases.

Option 2 is wrong. Melting point increases from Na to Si. Melting point of $S_8 > P_4 > Cl_2 > Ne$

Option 3 is wrong. The maximum oxidation state is shown by chlorine (+7).

Option 4 is correct. Aluminium oxide is the only oxide which is amphoteric as it can react with both acid and base.
$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$
$Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$

21 Vitamin C has the following structure.

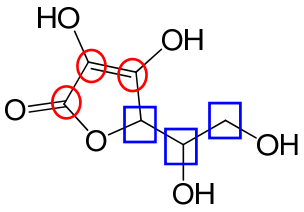


Vitamin C

How many sp^2 and sp^3 hybridised carbon atoms does this molecule have?

	sp^2	sp^3
A	6	0
B	4	2
C	3	3
D	2	4

Answer: C



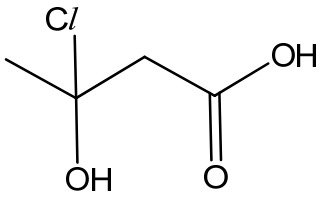
Vitamin C

sp^2 carbon: ○

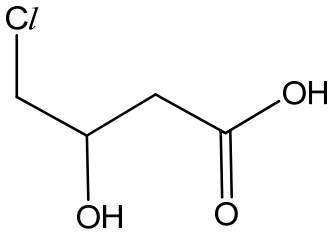
sp^3 carbon: □

22 Which structure correctly represents 4-chloro-3-hydroxybutanoic acid?

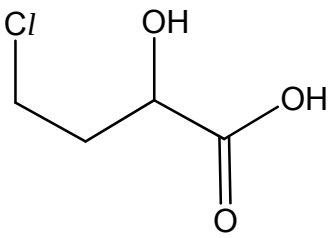
A



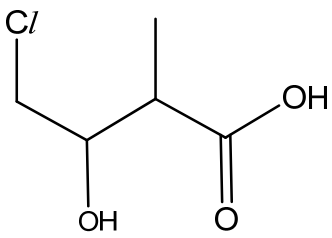
B



C



D



Answer: B

23 As the number of carbon atoms in a homologous series of alkane molecules **increases**, for which property of the alkanes does the numerical value **decrease**?

A density

B enthalpy change of vaporization

C number of isomers

D vapour pressure

Answer: D

Option A is wrong. As the number of carbon atom increases, the Mr of the molecule increases and density also increases.

Option B is wrong. As the number of carbon atom increases, the i.d.-i.d between the molecules increases as elctron cloud size increases, boiling point increases. The enthalpy change of vaporization also increases.

Option C is wrong. As the number of carbon atom increases, there are more number of isomers.

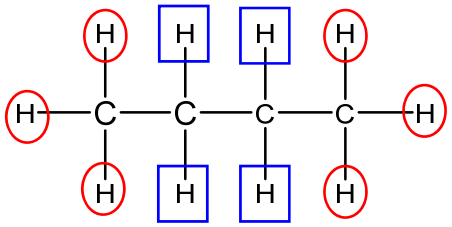
Option D is correct. As the number of carbon atom increases, the i.d.-i.d between the molecules increases as elctron cloud size increases, boiling point increases. Less molecules are vaporised and vapour pressure decreases.

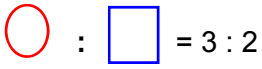
24 Compound **E**, C_4H_{10}, reacts with chlorine gas in the presence of light to form two monochlorinated alkanes, **F** and **G**, in an approximate molar ratio of 2 : 3.

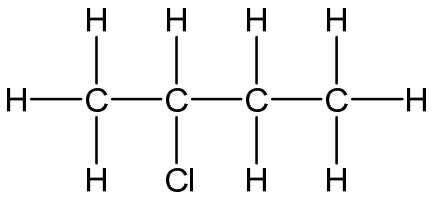
What are the structures of **E** and **F**?

	E	**F**
A	$CH_3CH(CH_3)CH_3$	$CH_3CH(CH_3)CH_2Cl$
B	$CH_3CH(CH_3)CH_3$	$CH_3CCl(CH_3)CH_3$
C	$CH_3CH_2CH_2CH_3$	$CH_3CH_2CHClCH_3$
D	$CH_3CH_2CH_2CH_3$	$CH_3CH_2CH_2CH_2Cl$

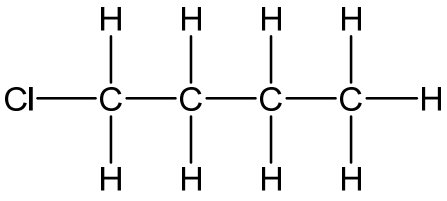
Answer: C







F



G

25 How many different alkenes, including cis-trans isomers, could be produced when 3-methylpentan-2-ol reacts with excess concentrated sulfuric acid at 170 °C?

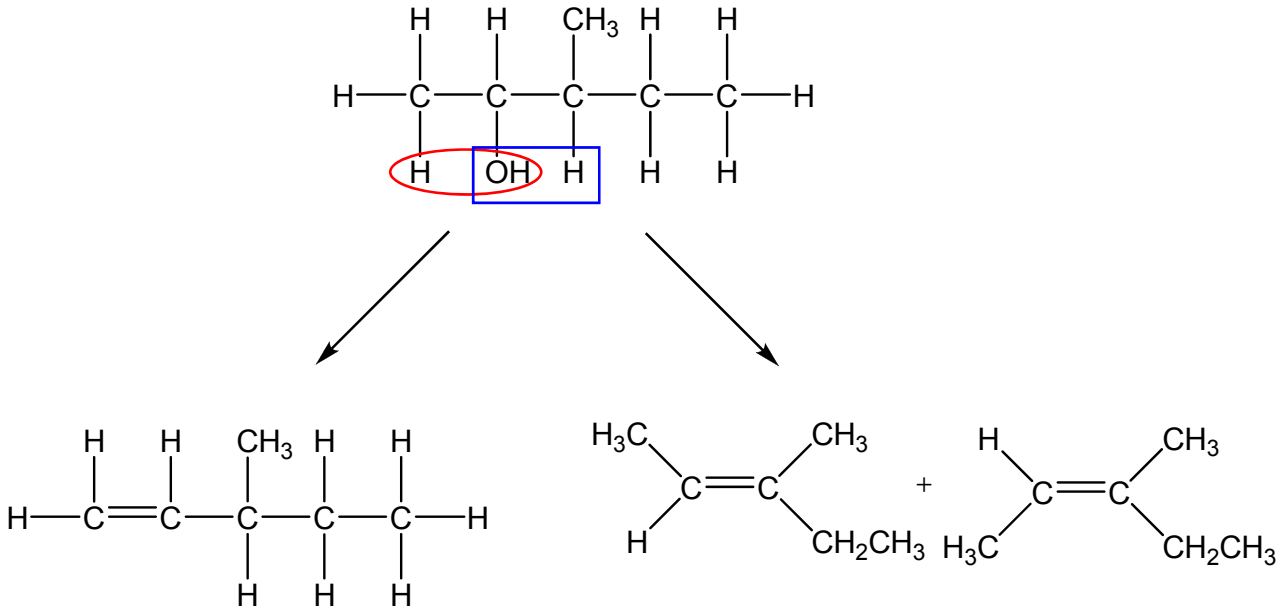
A 2

B 3

C 4

D 5

Answer: B



26 Lactic acid builds up in muscles when oxygen is in short supply. It can cause muscular pain. Part of the reaction sequence is shown.

$$\underset{\text{glyceraldehyde}}{CH_2OHCH(OH)CHO} \rightarrow \underset{\text{pyruvic acid}}{CH_3COCO_2H} \rightarrow \underset{\text{lactic acid}}{CH_3CH(OH)CO_2H}$$

Which statements about the reaction sequence are correct?

1 A secondary alcohol is oxidised to a ketone.

2 A ketone is reduced to a secondary alcohol.

3 An aldehyde is oxidised to a carboxylic acid.

4 A carboxylic acid is reduced to a primary alcohol.

A 1 and 2 only

B 1 and 4 only

C 1, 2 and 3 only

D 2, 3 and 4 only

Answer: C

Step 1: oxidation of secodary alcohol to ketone and oxidation of aldehyde to carboxylic acid

Step 2: reduction of ketone to secondary alcohol

27 A food chemist wants to create the odour of green apples for a product. An ester with this odour has the formula $CH_3CH_2CO_2CH(CH_3)_2$. In which of the following will the substances react together to produce this ester?

A CH_3CH_2OH and $(CH_3)_2CHCOOH$

B CH_3COOH and $CH_3CH(OH)CH_2CH_3$

C CH_3CH_2COOH and $CH_3CH_2CH_2OH$

D CH_3CH_2COOH and $(CH_3)_2CHOH$

Answer: D

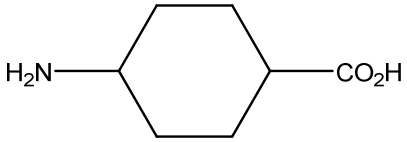
$CH_3CH_2CO_2CH(CH_3)_2 \rightarrow CH_3CH_2COOH + (CH_3)_2CHOH$ (acidic hydrolysis)

28 Which compound could be used by itself to form a condensation polymer?

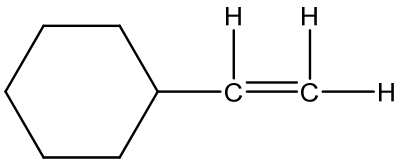
A $HOCH_2CH_2OH$

B $HO_2C(CH_2)_4CO_2H$

C



D



Answer: C

Option A cannot form condensation polymer as it only contains alcohol functional group.

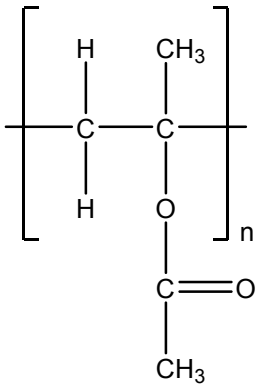
Option B cannot form condensation polymer as it only contains carboxylic acid functional group.

Option C can form condensation polymer as amine group and carboxylic acid group undergoes condensation to form amide.

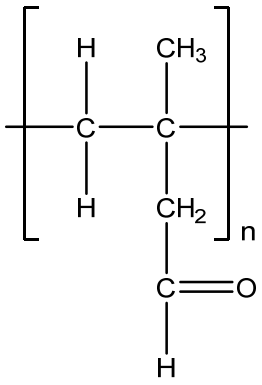
Option D cannot form condensation polymer but can form addition polymer.

29 The following polymers could be used for contact lenses. Contact lenses have to absorb water so that they can fit comfortably in the eyes. Which polymer will be the most suitable to be used for contact lens?

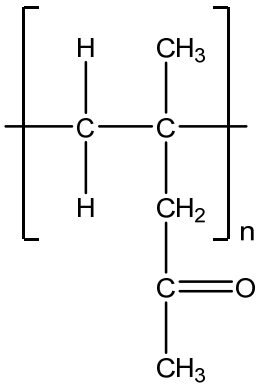
A



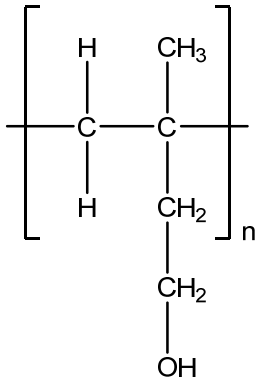
B



C



D



Answer: D

Structure D contains polar –OH group that can form hydrogen bonds with water, making it able to absorb water.

30 Which are the possible ways do nanomaterials enter the human body?

1 skin contact
2 inhalation
3 orally taken

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

Answer: D

End of Paper

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME					
CLASS		GROUP	**C / H / E / M**	INDEX NUMBER	

CHEMISTRY

8873/02

27 Aug 2018

2 hour

Paper 2 Structured Questions

Candidates answer on the question paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your index number, name and civics group.
Write in dark blue or black pen.
You may use pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the space provided.

Section B
Answer **1 out of 2** questions on writing paper provided..

A *Data Booklet* is provided.

You are advised to show all working in calculations.
You are reminded of the need for good English and clear presentation in your answers.
You are reminded of the need for good handwriting.
Your final answers should be in 3 significant figures.

You may use a calculator.

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

Paper 2	/67
Paper 1	/33
Overall	/100
Overall Grade	

For Examiner's Use	
Section A	
1	/12
2	/12
3	/8
4	/14
5	/14
Section B (Please circle)	
6 or 7	/20
Significant figures and units	
Handwriting	
P2 Total	/80
P1 Total	/30

This document consists of **20** printed pages.

Section A

Answer all the questions.

1 Magnesium, the eighth most abundant element on Earth, has diverse applications such as in building or medicine.

(a) **(i)** Write equations for the reactions of the oxides of magnesium and phosphorus with water.

……..

……..[2]

(ii) Write equations for the reactions of magnesium chloride and phosphorus chloride with water respectively. Include in your answer, the pH of the resultant solutions.

……..

……..

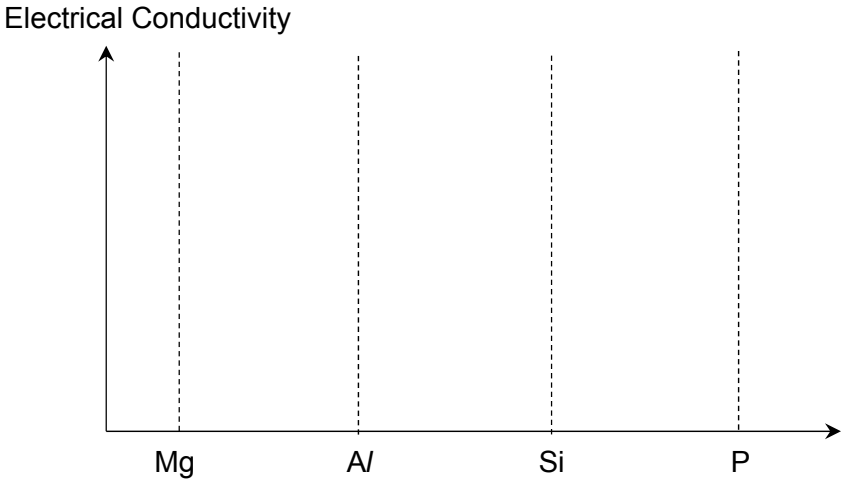
……..

……..

……..

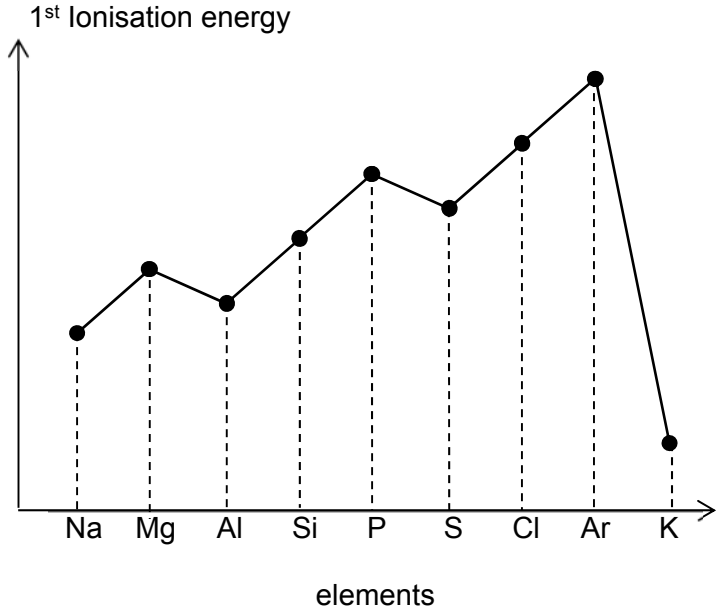
……..[4]

(iii) On the axes below, sketch the electrical conductivity of the period 3 elements from magnesium to phosphorous.



[1]

(b) The following graph shows the trend of the first ionisation energies of the elements from sodium to potassium.



(i) Explain the difference between the values of their first ionisation energies for **each** of the pairs of elements listed below. You should use a different explanation for each pair.

- sodium and potassium

……..

……..

……..

……..

……[2]

- magnesium and aluminium

……..

……..

……..

……..

……[1]

(ii) When a beam of $_{20}Ca^{2+}$ particles travels through a uniform electric field which is at right angles to its direction of travel, it is deflected at an angle of +10.0°.

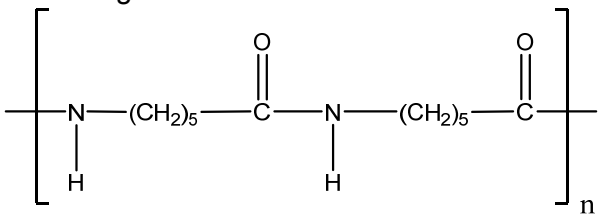
Determine the angle of deflection of a beam of $_{8}O^{2-}$ particles if it travels at the same speed through the same electric field.

[2]

[Total: 12]

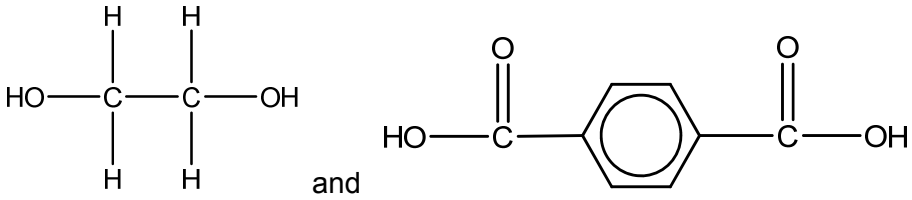
2 Synthetic polymer fibres are man-made, formed entirely by chemical synthesis. Demand for synthetic fibres has increased over the last few decades as they are durable, less expensive and more stain resistant than natural fibres. Terylene and Nylon 6 are examples of polymeric synthetic fibre.

- Nylon 6 has the following structure.



Nylon 6

- Terylene is made from ethane-1,2-diol and benzene-1,4-dicarboxylic acid:



(a) Draw the structural formula of the monomer from which Nylon 6 could be made. State the type of polymerisation involved.

Type of polymerisation: …… [2]

(b) Draw a displayed formula to show the simplest repeat unit of Terylene.

[1]

(c) Explain why nylon is prone to creasing while Terylene is wrinkle free.

……

……

……

…… [2]

Poly(propene) is also a polymer like the synthetic fibre; it is lightweight, durable and widely used in industries for making home articles such as container, buckets and crates.

(d) Explain why dilute sodium hydroxide will cause holes to appear in containers made from polymers such as Terylene but a poly(propene) container can be used to store sodium hydroxide.

……

…… [1]

(e) State the reason why the disposal of poly(propene) containers in landfill sites is a problem.

……

…… [1]

(f) The following is an extract from an article "The safety of *nanoparticles* in sunscreens: An update for general practice" published on The Royal Australian College of General Practitioners 2016, June 2016.

"Recent media coverage has raised public awareness regarding the safety of sunscreens containing zinc (ZnO) and titanium (TiO_2) *nanoparticles*. The inorganic filters ZnO and TiO_2 are able to protect against UVA and UVB. As conventional micronised particles in sunscreen, they have several unfavourable characteristics, including difficulty in application, leaving white residue on the skin. This led to the development of smaller *nanoparticles*, the use of which vastly improves aesthetic and ease of application of sunscreens while maintaining photo-protective qualities."

(i) Define *nanoparticles*.

…….. [1]

(ii) Explain in your own words why the surface-to-volume ratios makes nanoscale sunscreen attractive.

……

……

……

…….. [2]

(iii) Explain why nanoparticles of TiO_2 in sunscreen could present a risk to human health.

…….. [1]

(iv) Sunscreen containing nanoparticles should be tested further.
Suggest one reason why some companies that make sunscreens might not want to do more tests.

……

…….. [1]

[Total: 12]

3 Citric acid, $C_6H_8O_7$, is a weak tribasic organic acid. It is used as an additive and preservative in various food and drinks to enhance flavour and taste. It provides a fruity tartness to complement fruit flavours and it is also used to mask the unpleasant taste of pharmaceutical products.

However, a high content of citric acid in foods and drinks could damage your teeth. Chemical erosion of the teeth occurs either by the hydrogen ions derived from citric acid or by the citric acid anions which can bind or complex calcium. The acceptable limit for the percentage composition by mass of citric acid in food is 2.5% as this is around the percentage composition commonly found in natural fruits.

A student wanted to find the out the mass of citric acid in a mint candy by doing a titration with sodium hydroxide solution. The equation for the titration is:

$$C_6H_8O_7 + 3NaOH \rightarrow C_6H_5O_7Na_3 + 3H_2O$$

He weighed out 5.00 g of the mint candy and crushed the candy into powder. He then dissolved the powder in 100 cm^3 of distilled water, stirred the mixture and filtered it forming solution **A**.

(a) The student then prepared a standard solution of sodium hydroxide by dissolving 0.104 g of sodium hydroxide pellets in 25.0 cm^3 of distilled water. He then made the volume up to 250 cm^3 forming solution **B**.

Calculate the concentration of sodium hydroxide in solution **B**.

[2]

(b) The student then found that 20.0 cm^3 of solution **A** required 10.40 cm^3 of solution **B** for a complete reaction.

(i) Suggest a suitable indicator for the titration.

…….. [1]

(ii) Calculate the mass of citric acid in the 20.0 cm^3 of solution **A**.

[2]

(iii) Given that the average weight of one piece of mint candy is 0.50 g, calculate the mass of citric acid in one piece of mint candy.

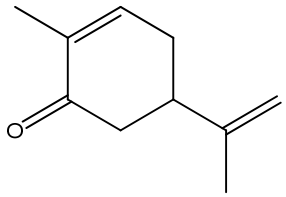
[2]

(c) From your answer in **(b) (iii)**, determine whether the percentage composition by mass of citric acid in the mint candy is above or below the acceptable limit.

[1]

[Total: 8]

4. Carvone is a natural oil produced by the plant *Mentha spicata.* It has the flavour of spearmint and it has important uses in food flavouring.



Carvone

(a) (i) Identify the functional groups present in Carvone.

……..[2]

(ii) Draw structures for the organic products of each compound with the following reagents. State the type of reaction in each case.

Reagent and conditions	**Type of reaction**	**Organic product**
Br_2 liquid, room temperature		
H_2 with Ni catalyst, high temperature and high pressure		
$LiAlH_4$ in dry ether, room temperature		

[7]

(b) Suggest why Carvone is highly soluble in hexane.

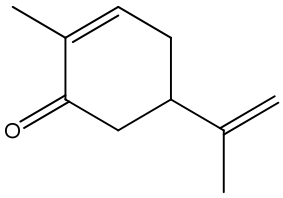
……

……

……

…… [2]

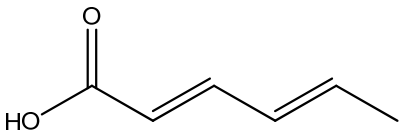
(c) On the above structure of Carvone, circle one sp^2 hybridised carbon atom.



Carvone

[1]

(d) Sorbic acid, or 2,4-hexadienoic acid, is a natural organic compound used as a food preservative.



Sorbic acid

Describe a chemical test that will help you distinguish Carvone from Sorbic acid, including all observations that would be made.

……

……

……

…… [2]

[Total: 14]

5 **(a)** Benzene undergoes complete combustion with oxygen as shown by the equation below.

$$C_6H_6(l) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

(i) Explain what is meant by *standard enthalpy change of combustion.*

……

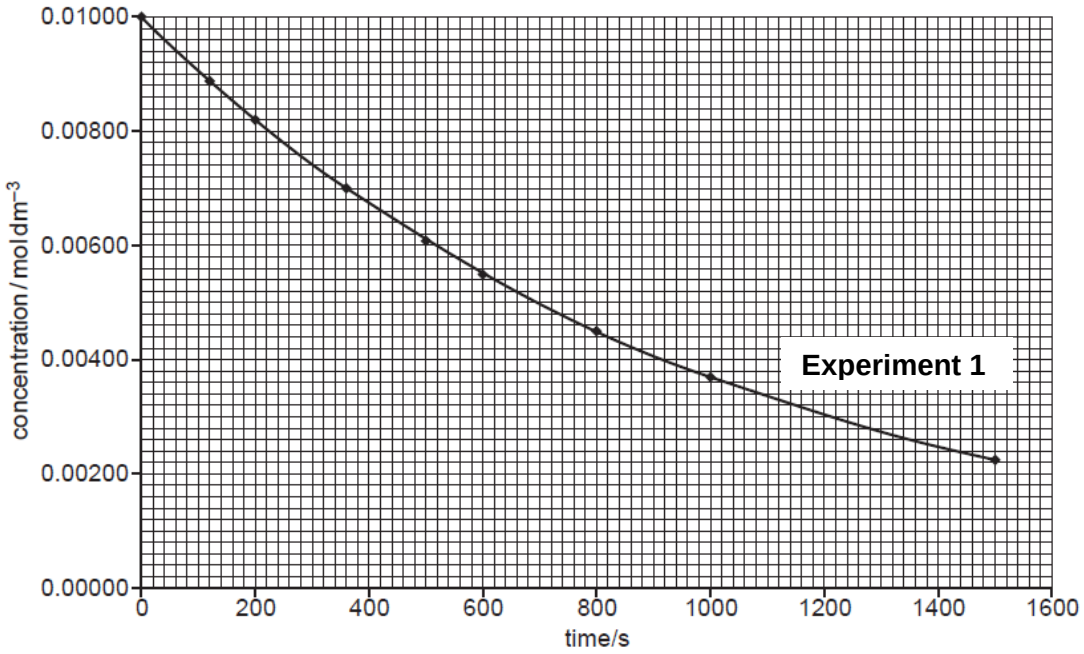
……...[1]

(ii) 1.17 g of benzene was burnt to heat up 250 g of water in a beaker. The initial temperature of the water was 27.6°C. Given that the standard enthalpy change of combustion of benzene is –3267 kJ mol^{-1} is and there is 20% heat loss to the surrounding, calculate the highest temperature reached by the water.

[3]

(b) 2–iodo–2–methylpropane undergoes a substitution reaction with hot aqueous sodium hydroxide. Two separate experiments were carried out to study the kinetics of this reaction.

In Experiment 1, sodium hydroxide was used in large excess and the concentration of 2–iodo–2–methylpropane was measured against time. A graph of concentration of 2–iodo–2–methylpropane against time was plotted and shown below**.**



(i) Use the half–life method to deduce the order of reaction with respect to 2–iodo–2–methylpropane. Show all your working clearly.

……..

……..

……[2]

In Experiment 2, 2–iodo–2–methylpropane was used in large excess and the concentration of sodium hydroxide was measured against time. The following results were obtained.

Time / s	[NaOH] / mol dm^{-3}
0	0.0100
100	0.0082
200	0.0064
380	0.0032
500	0.0010

(ii) Using the data provided above, plot a graph of [NaOH] vs time for Experiment 2 in the graph above.

[1]

(iii) Using the graph plotted in **(b)(ii)**, determine the order of reaction with respect to sodium hydroxide. Explain your answer.

……..

……..

……[2]

(iv) Hence, write an overall rate equation for the substitution reaction.

……[1]

(c) Colourless N_2O_4 and brown NO_2 are two oxides of nitrogen that can co-exist in equilibrium:

$$N_2O_4\ (g) \rightleftharpoons 2\ NO_2\ (g) \quad \Delta H = +\ 58\ kJ\ mol^{-1}$$

Predict and explain how the colour intensity of the mixture changes, when a reaction chamber containing an equilibrium mixture of N_2O_4 and NO_2 is:

(i) immersed in boiling water.

……

……

……

……

……[2]

(ii) subjected to a sudden compression in volume.

……

……

……

……

……[2]

[Total: 14]

Section B

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

6 (a) (i) Describe the structure of graphite. Explain how this structure gives graphite the properties of soft and high electrical conductivity.

You may include labelled diagrams in your answer.

……

……

……

……

……

……..[3]

(ii) Another allotrope of carbon is diamond. State one physical property diamond has in common with graphite and relate the property to the bonding present in their structures.

……

……

……..[2]

(b) (i) Write an equation, including state symbols, for the reaction with enthalpy change equal to the standard enthalpy of formation for ethane, $C_2H_6(g)$.

……..[1]

(ii) Suggest in terms of bonding why ethane is a gas at room temperature.

……

……..[1]

(iii) Ethane undergoes a reaction with chlorine. Name the type of reaction that occurs and the conditions used.

……

……..[2]

(c) The enthalpy change for the following reaction is –2889 kJ mol^{-1}.

$$C_2H_6(g) + 7F_2(g) \longrightarrow 2CF_4(g) + 6HF(g)$$

Use this value and the standard enthalpies of formation given to calculate the standard enthalpy of formation of $C_2H_6(g)$.

Substance	$CF_4(g)$	$HF(g)$
ΔH_f^o / kJ mol^{-1}	–680	–269

[2]

(d) Methane reacts violently with fluorine according to the following equation.

$$CH_4(g) + 4F_2(g) \longrightarrow CF_4(g) + 4HF(g) \qquad \Delta H = -1904 \text{ kJ mol}^{-1}$$

(i) Using relevant bond energies in the Data Booklet, calculate the bond energy of F–F bond.

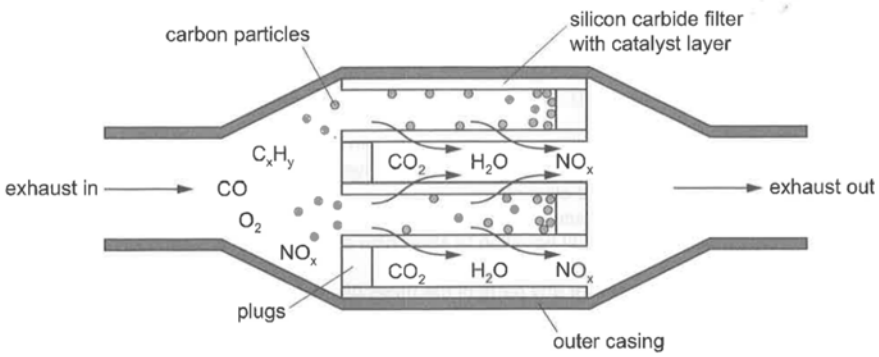
[2]

(ii) A student suggested that actual bond energy of F-F differs from theoretically calculated value in **(i)**. Explain if you agree or disagree with the student.

……

……[1]

(e) Catalyst are used in car exhaust of modern cars to speed up reaction between polluting gases such as carbon monoxide and dinitrogen oxide, before they reach the end of the exhaust pipe.



(i) State the type of catalyst involved in this reaction.

…….. [1]

(ii) Sketch a Boltzmann distribution curve for the reactants and use it to explain how the use of catalyst speeds up the reaction.

Explanation

……

……

……

……

……[4]

(iii) Suggest why car manufacturers are required to fit catalytic converters to car exhaust systems.

……

…….. [1]

[Total: 20]

7 **(a)** Phosphorus reacts with fluorine to form PF_3 and PF_5.

(i) Draw the dot-and-cross diagram for one molecule of PF_5. Show only the outer shell electrons.

[1]

(ii) Explain why the P–F bond is polar.

…….. [1]

(iii) Predict whether or not a molecule of PF_5 is polar. Explain your answer.

……

…….. [1]

(iv) Nitrogen reacts with fluorine to form NF_3 only.

Explain why PF_5 exists whereas NF_5 does not exist.

……

…….. [1]

(b) The reaction between sulfur dioxide and oxygen is a reversible reaction and can be described as being in dynamic equilibrium.

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

A 2-dm^3 reaction vessel containing 0.80 mol of SO_2, 0.30 mol of O_2 and 1.40 mol of SO_3 is allowed to reach equilibrium at a constant temperature of 1000 K. It was determined that 0.42 mol of SO_2 is present at equilibrium.

(i) State the meaning of the term *dynamic equilibrium*.

……

…….. [1]

(ii) Use the information given to complete Table 6.1.

Table 6.1

	SO_2	O_2	SO_3
Initial amount/ mol			
Equilibrium amount/ mol			

[2]

(iii) Write an expression for the equilibrium constant K_c.

[1]

(iv) Calculate the value of K_c. State the units of K_c.

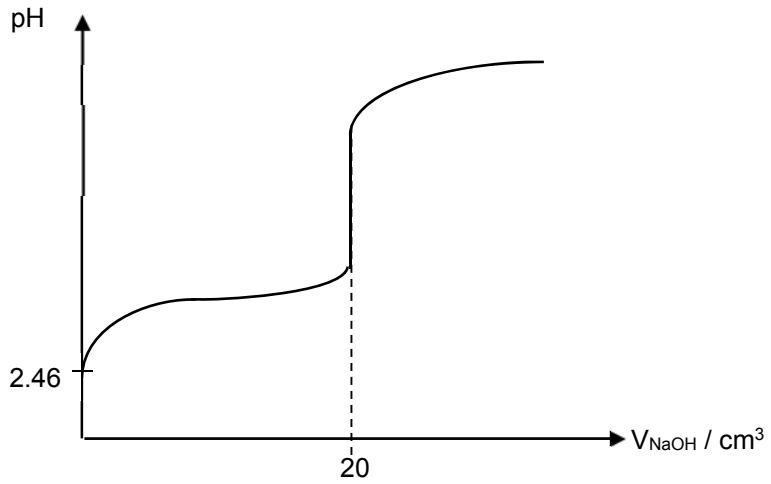
[2]

(c) (i) State the difference between a weak acid and a strong acid.

……

…….. [1]

20.0 cm^3 of 0.01 mol dm^{-3} propanoic acid, CH_3CH_2COOH was titrated against 0.01 mol dm^{-3} aqueous sodium hydroxide.



The initial pH of propanoic acid is 2.46.

(ii) Calculate the initial concentration of hydrogen ions before the titration.

[1]

During the addition of the first 20 cm^3 of sodium hydroxide the mixture is behaving as a buffer.

(iii) Explain how the shape of the graph show this.

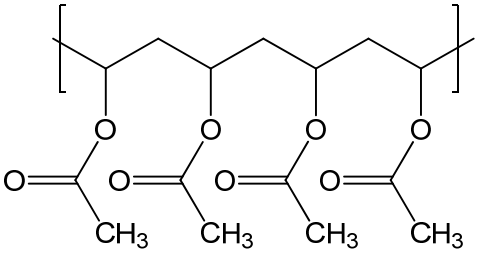
……

…….. [1]

(iv) Identify the two species present in the mixture that constitutes to it behaving as a buffer.

…….. [1]

(d) Polyvinyl acetate, PVAc, is a useful adhesive for gluing together articles made from wood, paper or cardboard. The diagram shows a section (not a repeat unit) of the PVAc.



PVAc

(i) What type of polymerisation made this polymer?

…….. [1]

(ii) PVAc is made from monomer **X**. Draw the structure of the **X**.

[1]

(iii) PVAc can be converted to polyvinyl alcohol, PVA.

Draw a section of PVA containing at least 2 repeat units and suggest the reagents and conditions needed to make PVA from PVAc in the laboratory.

Section of PVA:

Reagents and conditions: ……..

[2]

(e) The diagrams below are molecular representations of two types of plastics – thermoplastics and thermosets.

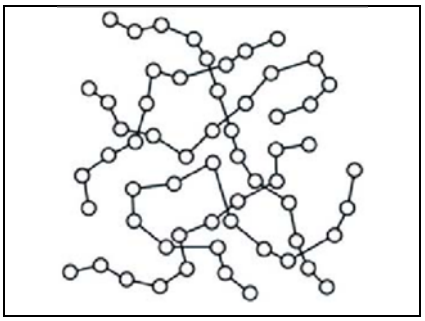


Diagram **A**

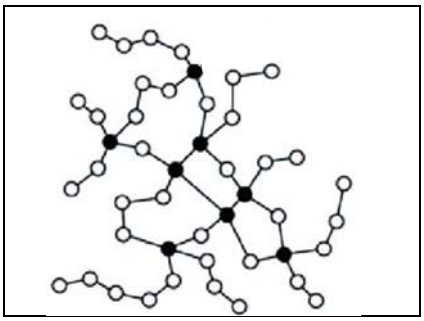


Diagram **B**

(i) State and explain which diagram could be the representation for thermosets.

……

…….. [1]

(ii) State a difference in physical properties between thermoplastics and thermosets.

……

…….. [1]

[Total: 20]

End of Paper

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME	**Suggested Answer**		
CLASS		INDEX NUMBER	

CHEMISTRY

8873/02

XX XXX 2018

2 hour

Paper 2 Structured Questions

Candidates answer on the question paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your index number, name and civics group.
Write in dark blue or black pen.
You may use pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the space provided.

Section B
Answer **1 out of 2** questions on writing paper provided..

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You are advised to show all working in calculations.
You are reminded of the need for good English and clear presentation in your answers.
You are reminded of the need for good handwriting.
Your final answers should be in 3 significant figures.

You may use a calculator.

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

Paper 2	/67
Paper 1	/33
Overall	/100
Overall Grade	

For Examiner's Use	
Section A	
1	/12
2	/12
3	/10
4	/12
5	/14
Section B (Please circle)	
6 or 7	/20
Significant figures and units	
Handwriting	
P2 Total	/80
P1 Total	/30

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

Section A

Answer all the questions.

1 Magnesium, the eighth most abundant element on Earth, has diverse applications such as in building or medicine.

(a) **(i)** Write equations for the reactions of the oxides of magnesium and phosphorus with water.

……..

……..[2]

$MgO\,(s) + H_2O\,(l) \rightleftharpoons Mg(OH)_2\,(aq)$ **[1] (mark for reversible arrow)**
$P_4O_{10}\,(s) + 6H_2O(l) \rightarrow 4H_3PO_4\,(aq)$ **[1]**

(ii) Write equations for the reactions of magnesium chloride and phosphorus chloride with water respectively. Include in your answer, the pH of the resultant solutions.

……..

……..

……..

……..

……..

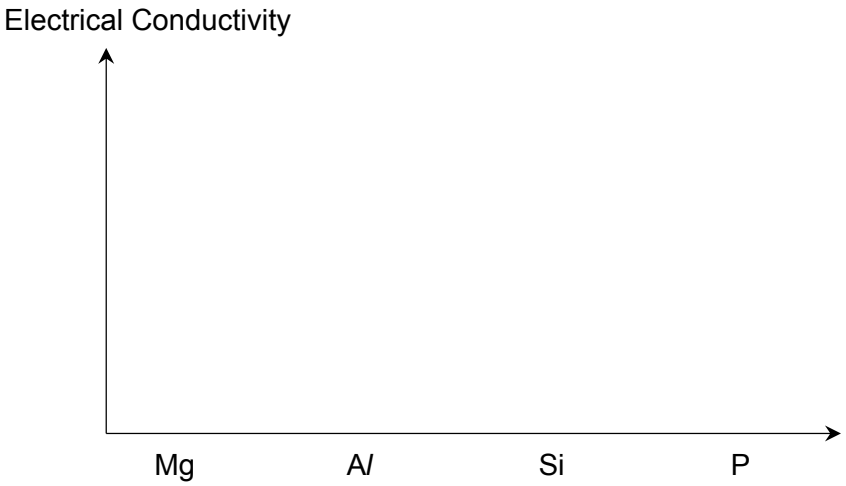
……..[4]

$MgCl_2 + 6H_2O \rightarrow [Mg(H_2O)_6]^{2+} + 2Cl^-$
$[Mg(H_2O)_6]^{2+} + H_2O \rightleftharpoons [Mg(H_2O)_5(OH)]^+ + H_3O^+$

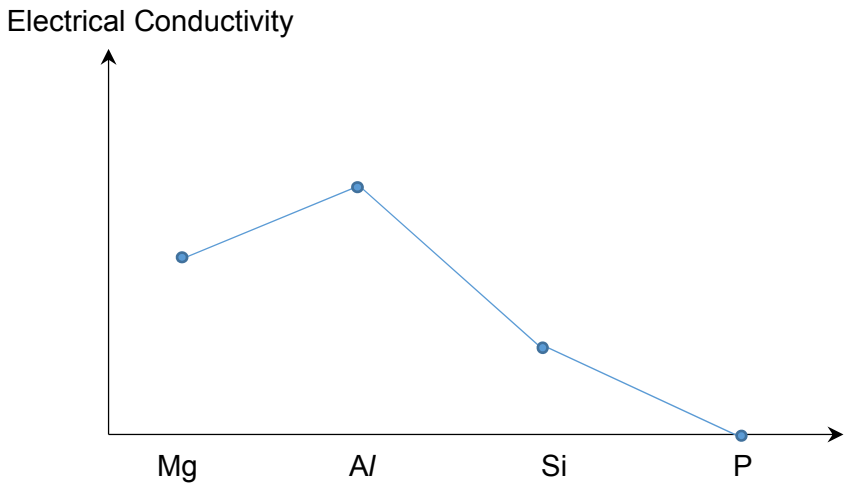
Magnesium chloride solution: **pH 6.5**.

$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$
Phosphorus chloride solution: **pH 1-2**.

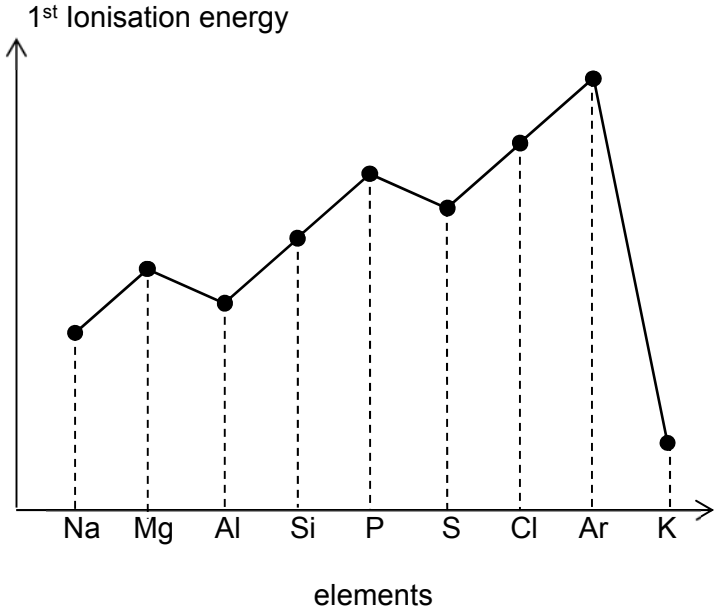
(ii) On the axes below, sketch the electrical conductivity of the period 3 elements from magnesium to phosphorous.



[1]



(b) The following graph shows the trend of the first ionisation energies of the elements from sodium to potassium.



(i) Explain the difference between the values of their first ionisation energies for **each** of the pairs of elements listed below. You should use a different explanation for each pair.

- sodium and potassium

……..

……..

……..

……..

……[2]

$_{11}Na$: $1s^2\ 2s^2\ 2p^6\ 3s^1$ $_{19}K$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

K has one more quantum shell of electrons than Na, **valence electron of K is further away from the nucleus** and **less strongly attracted to the nucleus. Less energy is required to remove the valence electrons from K**.

Hence 1st IE of K is lower than that of Na.

- magnesium and aluminium

……..

……..

……..

……..

……[1]

Mg: $1s^2\ 2s^2\ 2p^6\ 3s^2$ Al: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

The **3p electron of Al is further away from the nucleus and has higher energy than the 3s electron of Mg**. **Less energy is required to remove the 3p electron from Al.** Thus, 1st IE of Mg is higher than that of Al.

(ii) When a beam of $_{20}Ca^{2+}$ particles travels through a uniform electric field which is at right angles to its direction of travel, it is deflected at an angle of +10.0°.

Determine the angle of deflection of a beam of $_8O^{2-}$ particles if it travels at the same speed through the same electric field.

[2]
[Total: 12]

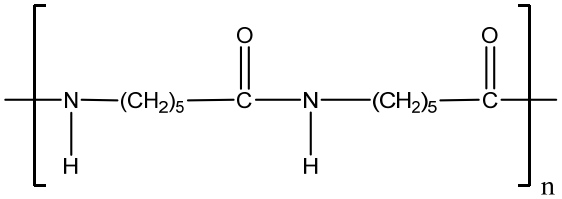
angle of deflection $\propto \frac{\mathbf{q}}{\mathbf{m}}$

Particle	z/m ratio	angle of deflection
Ca^{2+}	+2/40.1	+10.0°
O^{2-}	-2/16	[(-2/16 / (+2/40)] x (+10.0) = **-25°**

correct magnitude
correct sign

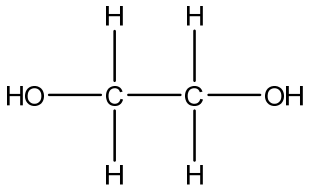
2 Synthetic polymer fibres are man-made, formed entirely by chemical synthesis. Demand for synthetic fibres has increased over the last few decades as they are durable, less expensive and more stain resistant than natural fibres. Terylene and Nylon 6 are examples of polymeric synthetic fibre.

- Nylon 6 has the following structure.

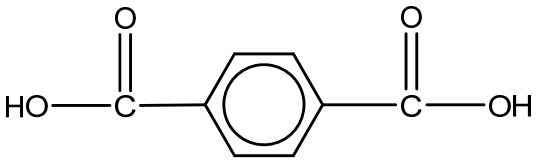


Nylon 6

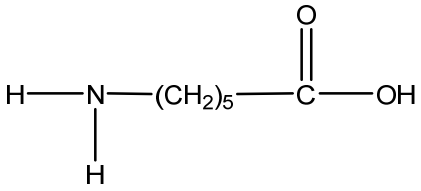
- Terylene is made from ethane-1,2-diol and benzene-1,4-dicarboxylic acid.



and



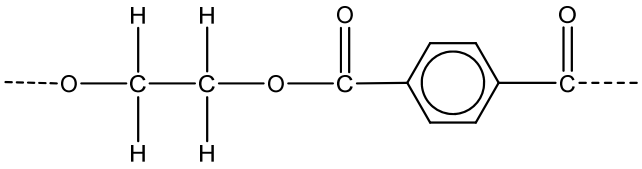
(a) Draw the structural formula of the monomers from which Nylon 6 could be made. State the type of polymerisation involved.



Type of polymerisation: Condensation polymerisation

[2]

(b) Draw a displayed formula to show the simplest repeat unit of Terylene. [1]



(c) Explain why nylon is prone to creasing while Terylene is wrinkle free.

……

……

……

…… [2]

Nylon: Polyamide chains are bonded to one another via hydrogen bonding. The hydrogen bonds are broken / disturbed when water penetrate the areas between the chains. New hydrogen bonds are formed while it dries up and form creases.

Terylene: a polyester which do not form hydrogen bonding between the chains, thus is less prone to crease.

Poly(propene) is also a polymer like the synthetic fibre; it is lightweight, durable and widely used in industries for making home articles such as container, buckets and crates.

(d) Explain why dilute sodium hydroxide will cause holes to appear in containers made from polymers such as Terylene but a poly(propene) container can be used to store sodium hydroxide. [1]

……

…… [1]

Terylene (Polyesters) are susceptible to/undergoes **hydrolysis** in presence of alkali but poly(propene) is unreactive towards alkali.

(e) State the reason why the disposal of poly(propene) containers in landfill sites is a problem. [1]

……

…… [1]

PP is not easily decomposed in nature/break down by microorganisms/non-biodegradable.
Thus, takes up land space.

(f) The following is an extract from an article "The safety of nanoparticles in sunscreens: An update for general practice" published on The Royal Australian College of General Practitioners 2016, June 2016.

"Recent media coverage has raised public awareness regarding the safety of sunscreens containing zinc (ZnO) and titanium (TiO_2) nanoparticles. The inorganic filters ZnO and TiO_2 are able to protect against UVA and UVB. As conventional micronised particles in sunscreen, they have several unfavourable characteristics, including difficulty in application, leaving white residue on the skin. This led to the development of smaller nanoparticles, the use of which vastly improves aesthetic and ease of application of sunscreens while maintaining photo-protective qualities."

(i) Define nanoparticles.

…… [1]

Material with all dimensions on 1-100 nm.

(ii) Explain in your own words why the surface-to-volume ratios makes nanoscale sunscreen attractive.

……

……

……

…… [2]

As surface area to volume ratio is high, a greater amount of a blocking agent (sunscreen) is in contact with the nanoparticle. The denser packing covers the skin more evenly/ does not leave bulky residue behind. (or words to the same effect)

(iii) Explain why nanoparticles of TiO_2 in sunscreen could present a risk to human health.

…… [1]

it can easily pass through/absorb into pores/ skin/ cell / membranes / veins/ capillaries/ into blood stream AND get into blood and cause cancer / toxic to cells

(iv) Sunscreen containing nanoparticles should be tested further.

Suggest one reason why some companies that make sunscreens might not want to do more tests.

……

…… [1]

1 of the possible answers:

- Testing is time-consuming
- Testing is expensive
- Testing may result in undesirable outcome / reduce sales (owtte)
- Accept other logical answers

3 Citric acid, $C_6H_8O_7$, is a weak tribasic organic acid. It is used as an additive and preservative in various food and drinks to enhance flavour and taste. It provides a fruity tartness to complement fruit flavours and it is also used to mask the unpleasant taste of pharmaceutical products.

However, a high content of citric acid in foods and drinks could damage your teeth. Chemical erosion of the teeth occurs either by the hydrogen ions derived from citric acid or by the citric acid anions which can bind or complex calcium. The acceptable limit for the percentage composition by mass of citric acid in food is 2.5% as this is around the percentage composition commonly found in natural fruits.

A student wanted to find the out the mass of citric acid in a mint candy by doing a titration with sodium hydroxide solution. The equation for the titration is:

$$C_6H_8O_7 + 3NaOH \rightarrow C_6H_5O_7Na_3 + 3H_2O$$

He weighed out 5.00 g of the mint candy and crushed the candy into powder. He then dissolved the powder in 100 cm^3 of distilled water, stirred the mixture and filtered it forming solution **A**.

(a) The student then prepared a standard solution of sodium hydroxide by dissolving 0.104 g of sodium hydroxide pellets in 25.0 cm^3 of distilled water. He then made the volume up to 250 cm^3 forming solution **B**.

Calculate the concentration of sodium hydroxide in solution **B**.

Amount of NaOH in 25.0 cm^3 of distilled water = 0.104/40.0 = 0.002594 mol

[NaOH] in solution B = 0.002594 x (1000/250) = 0.0104 mol dm^{-3}

[2]

(b) The student then found that 20.0 cm^3 of solution **A** required 10.40 cm^3 of solution **B** for a complete reaction.

(i) Suggest a suitable indicator for the titration.

Phenolphthalein.
Do not accept methyl orange or universal indicator.

[1]

(ii) Calculate the mass of citric acid in the 20.0 cm^3 of solution **A**.

ECF from (a)(i)

Amount of Citric acid in 20.0 cm^3 of **A** = (10.40/1000) x 0.0104 x (1/3)
= 3.605 x 10^{-5} mol

Molar mass of citric acid = 192.0 g mol^{-1}

Mass of citric acid in 20.0 cm^3 of **A** = 3.605 x 10^{-4} x 192.0
= 0.00692 g

[2]

(iii) Given that the average weight of one piece of mint candy is 0.50 g, calculate the mass of citric acid in one piece of mint candy.

Mass of citric acid in 100.0 cm^3 of **A** = 0.00692 x 5 = 0.0346g

Mass of citric acid in one piece of mint candy = (0.0346/5.00) x 0.5
= 0.00346 g

[2]

(c) From your answer in **(b) (iii)**, determine whether the percentage composition by mass of citric acid in the mint candy is above or below the acceptable limit.

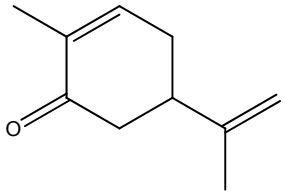
Percentage composition of citric acid by mass = 0.00346/0.5 x 100%
= 0.692 %

The percentage composition is **below** the acceptable limit.

[1]

[Total: 10]

4. Carvone is a natural oil produced by the plant *Mentha spicata.* It has the flavour of spearmint and it has important uses in food flavouring.



Carvone

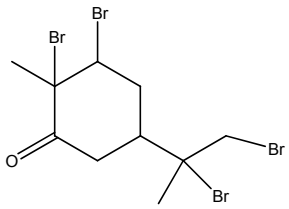
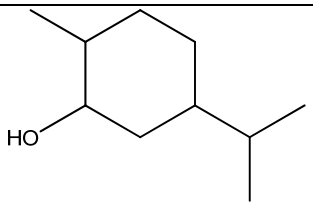
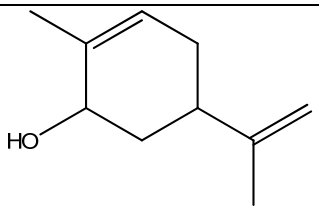
(a) Carvone reacts with different reagents

(i) Identify the functional groups present in Carvone.

Alkene and **ketone** (Do not accept alkane or carbonyl)

[2]

(ii) Draw structures for the organic products of each compound with the following reagents. State the type of reaction that is happening for each reagent.

Reagent and conditions	Type of reaction	Organic product
Br_2 liquid, room temperature	Addition	
H_2 with Ni catalyst, high temperature and high pressure	Reduction	
$LiAlH_4$ in dry ether, room temperature	Reduction	

[7]

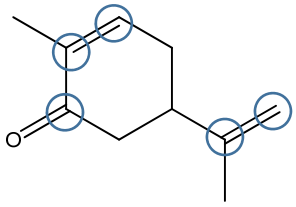
(b) Suggest why Carvone is highly soluble in hexane.

Carvone has **a bulky hydrocarbon chain**/ **many C-C and C-H bonds** that enables it to form **instantaneous dipole – induced dipole interactions** with hexane molecules.

[2]

(c) On the above structure of Carvone, circle one sp^2 hybridised carbon atom.

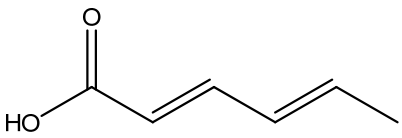
[1]



Carvone

Any one of the 5 circled Cs

(d) Sorbic acid, or 2,4-hexadienoic acid, is a natural organic compound used as a food preservative.



Sorbic acid

Describe a chemical test that will help you distinguish Carvone from Sorbic acid, including all observations that would be made.

Add **sodium carbonate** to both Carvone and sorbic acid.

Sorbic acid will give **effervescence**. Gas produced forms a white precipitate with calcium hydroxide.

No observable change will be seen for Carvone.

[2]
[Total: 14]

5 **(a)** Benzene undergoes complete combustion with oxygen as shown by the equation below.

$$C_6H_6(l) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

(i) Explain what is meant by *standard enthalpy change of combustion.*

……

……[1]

It is the enthalpy change when one mole of a compound is completely burnt in oxygen under standard conditions of 298K and 1 atm.

(ii) 1.17 g of benzene was burnt to heat up 250 g of water in a beaker. The initial temperature of the water was 27.6°C. Given that the standard enthalpy change of combustion of benzene is –3267 kJ mol^{-1} is and there is 20% heat loss to the surrounding, calculate the highest temperature reached by the water.

[3]

Amount of benzene = 1.17 / (12.0 × 6 + 1.0 × 6) = **0.0150 mol**

Total amount of heat evolved = 0.0150 × (-3267) = **- 49.01 kJ**

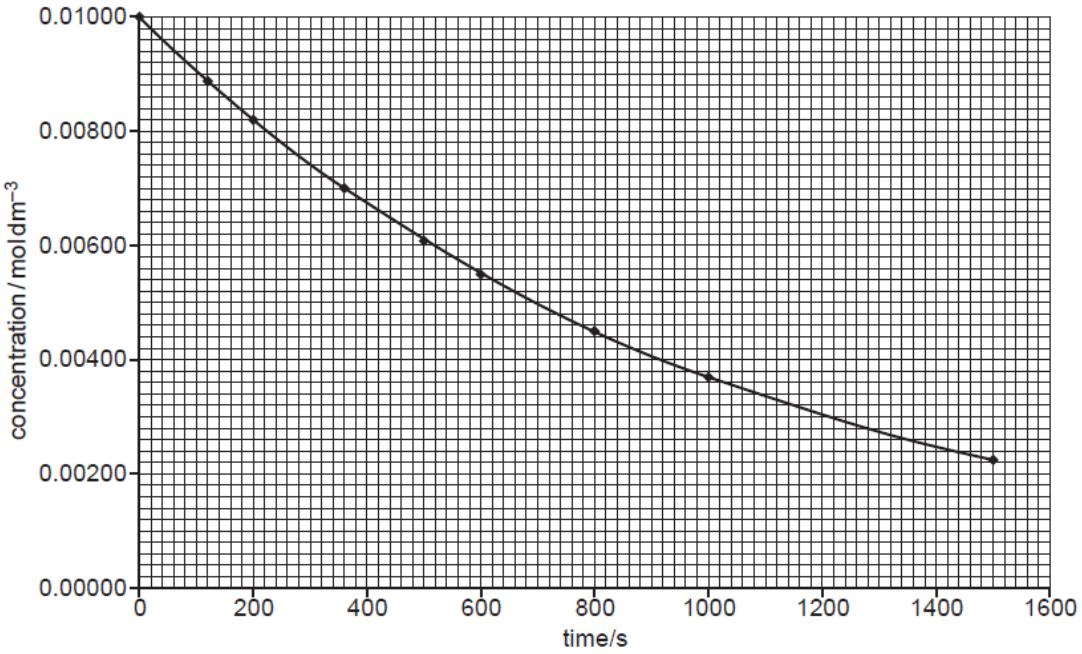
Amount of heat absorbed by the water = **0.80 × 49.005** = 39.20 kJ

Heat absorbed by water = mcΔT
$39.20 \times 10^3 = 250 \times 4.18 \times \Delta T$
$\Delta T = 37.5°C$

Highest temperature reached = **27.6 + 37.5** = 65.1°C

(b) 2–iodo–2–methylpropane undergoes a substitution reaction with hot aqueous sodium hydroxide. Two separate experiments were carried out to study the kinetics of this reaction.

In Experiment 1, sodium hydroxide was used in large excess and the concentration of 2–iodo–2–methylpropane was measured against time. A graph of concentration of 2–iodo–2–methylpropane against time was plotted and shown below**.**



(i) Use the half–life method to deduce the order of reaction with respect to 2–iodo–2–methylpropane. Show all your working clearly.

……

……

……[2]

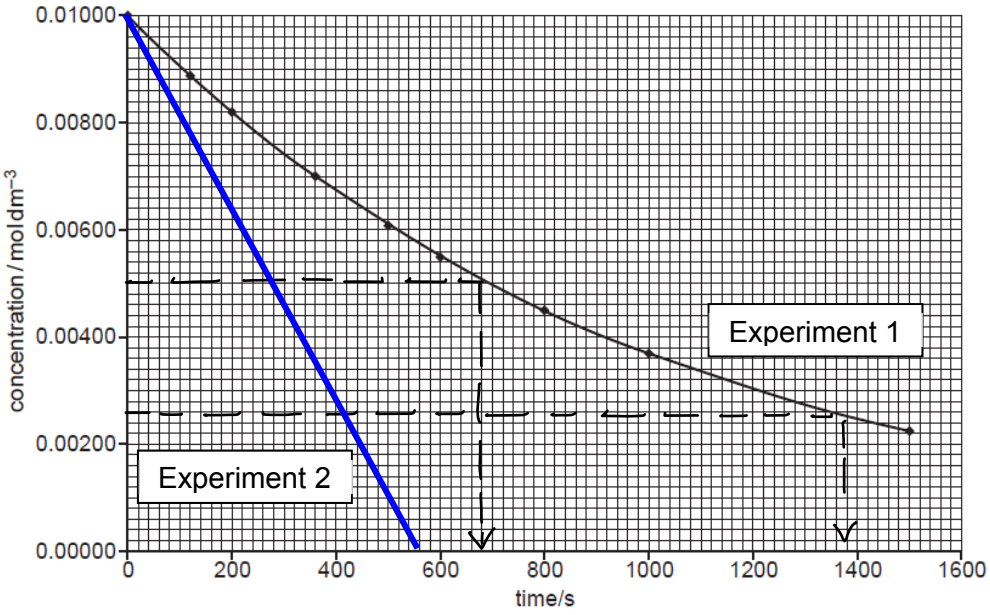
Show clear construction lines to obtain two half lives.
Two approximately constant half-lives obtained ≈ 690 ± 10 s

Order of reaction w.r.t 2-iodo-2-methylpropane = **1**

In Experiment 2, 2–iodo–2–methylpropane was used in large excess and the concentration of sodium hydroxide was measured against time. The following results were obtained.

Time / s	[NaOH] / mol dm^{-3}
0	0.0100
100	0.0082
200	0.0064
380	0.0032
500	0.0010

(ii) Using the data provided above, plot a graph for Experiment 2 in the graph above. [1]



Points correctly plotted.
Best fit straight line.

(iii) Using the graph plotted in **(b)(ii)**, determine the order of reaction with respect to sodium hydroxide. Explain your answer.

……..

……..

……[2]

From experiment 2,
[NaOH] vs time graph is a straight line
=> constant gradient => constant rate
(=> rate is independent of [NaOH])

Hence order of reaction w.r.t. NaOH = 0

(iv) Hence, write an overall rate equation for the substitution reaction.

……[1]

rate = k [2-iodo-2-methylpropane]

(c) Colourless N_2O_4 and brown NO_2 are two oxides of nitrogen that can co-exist in equilibrium:

$$N_2O_4\ (g) \rightleftharpoons 2\ NO_2\ (g) \quad \Delta H = +\ 58\ kJ\ mol^{-1}$$

Predict and explain how the colour intensity of the mixture changes, when a reaction chamber containing an equilibrium mixture of N_2O_4 and NO_2 is:

(i) immersed in boiling water.

.....

.....

.....

.....

.....[2]

When there is an increase in temperature, **equilibrium shifts right** to **favour the endothermic reaction** to **absorb the additional heat**, producing more NO_2, leading to an **increase in colour intensity**.

(ii) subjected to a sudden compression in volume.

.....

.....

.....

.....

.....[2]

When there is a sudden compression of the reaction chamber, the pressure of the system increase. By Le Chatelier's Principle, the **equilibrium position shifts to the left** , **favouring the production of fewer gaseous molecules**, producing more N_2O_4, leading to a **decrease in colour intensity.**

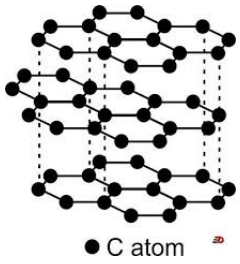
[Total: 14]

Section B

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

5 (a) Describe the structure of graphite. Explain how this structure gives graphite the properties of soft and high electrical conductivity.

You may include labelled diagrams in your answer.



- They have parallel layers of hexagons or shown in diagram
- **Soft:** The adjacent layers are held by **weak id–id interactions** and hence the layers **can slide easily over** one another.
- **Electrical conductivity**: One p electron per C atom (out of the 4 electrons) is **delocalised**, thus is able to conduct electricity well (parallel to layer).

……

……

……

……

……[3]

(ii) Another allotrope of carbon is diamond. State one physical property diamond has in common with graphite and relate the property to the bonding present in their structures.

They have high melting points
due to the strong extensive covalent bonds between atoms

……

……

……[2]

(b) (i) Write an equation, including state symbols, for the reaction with enthalpy change equal to the standard enthalpy of formation for ethane, $C_2H_6(g)$.

$$2C\ (s) + 3H_2(g) \longrightarrow C_2H_6(g)$$

……[1]

(ii) Suggest in terms of bonding why ethane is a gas at room temperature.

Small amount of energy is required to break the weak instantaneous dipole induced dipole interactions between the ethane molecules.

id-id between molecules AND small amount of energy/weak bonds

……

……[1]

(iii) Ethane undergoes a reaction with chlorine. Name the type of reaction that occurs and the conditions used.

Substitution reaction Presence of uv light

……

……[2]

(b) **(i)** The enthalpy change for the following reaction is –2889 kJ mol^{-1}.

$$C_2H_6(g) + 7F_2(g) \longrightarrow 2CF_4(g) + 6HF(g)$$

Use this value and the standard enthalpies of formation given to calculate the standard enthalpy of formation of $C_2H_6(g)$.

Substance	$CF_4(g)$	$HF(g)$
ΔH_f^o / kJ mol^{-1}	–680	–269

$\Delta H_r^\theta = \sum n\Delta H_f^\theta$ **(products) –** $\sum m\Delta H_f^\theta$ **(reactants)**

–2889 = (2 x –680) + (6x–269) – ΔH_f^o $C_2H_6(g)$ mtd

ΔH_f^o $C_2H_6(g)$ = – 85 kJ mol^{-1} ans

[2]

(c) Methane reacts violently with fluorine according to the following equation.

$$CH_4(g) + 4F_2(g) \longrightarrow CF_4(g) + 4HF(g) \qquad \Delta H = -1904 \text{ kJ mol}^{-1}$$

(i) Using relevant bond energies in the Data Booklet, calculate the bond energy of F–F bond. [2]

Bonds broken (endothermic)	**No. of moles**	**Bond energy / kJ mol^{-1}**
C–H	4	4 X 410
F–F	4	4 X F–F

Bonds formed (exothermic)	**No. of moles**	**Bond energy / kJ mol^{-1}**
C–F	4	4 x 485
H–F	4	4 x 562

$\triangle H_{reaction}$ = Total bonds broken – total sum of bonds formed

–1904 = (4 X 410) + (8 X F–F) – [(4 x 485) + (4 x 562)] mtd [1] / shown in table

F–F bond = +161 kJ mol^{-1} ans with correct sign

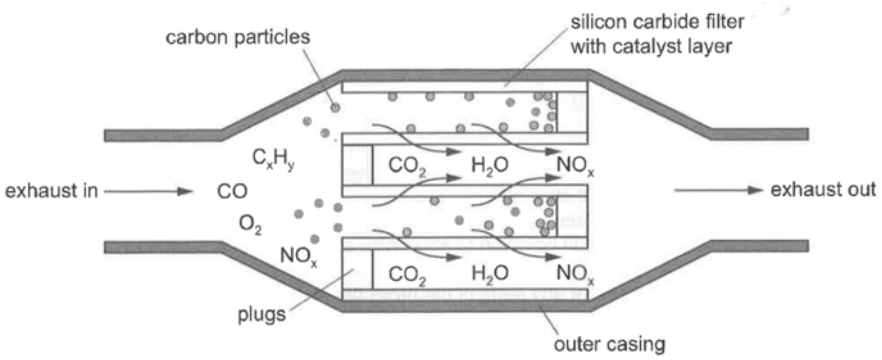
(ii) A student suggested that actual bond energy of F-F differs from theoretically calculated value in (i). Explain if you agree or disagree with the student.

I agree with the student.
The bond energies used to calculate the (i) are only average values obtained from the Data Booklet.

……

……[1]

(c) (i) Catalyst are used in car exhaust of modern cars to speed up reaction between polluting gases such as carbon monoxide and dinitrogen oxide, before they reach the end of the exhaust pipe.



(i) State the type of catalyst involved in this reaction.

…… [1]
Heterogeneous catalyst (catalyst and reactants are in **different** phase)

(ii) Sketch a Boltzmann distribution curve for the reactants and use it to explain how the use of catalyst speeds up the reaction.

Diagram

Explanation

.....

.....

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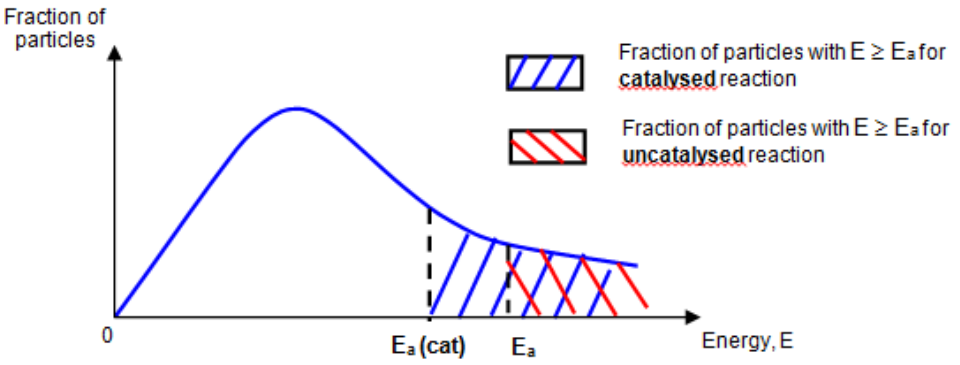
.....

.....

[4]



- Catalyst **lowers the activation energy by providing an alternative reaction pathway.** (shown in graph)

- **Fraction of particles with energy equal to or greater than the activation energy of the catalysed reaction, $E_{a(cat)}$ increases.**

- **Increased frequency of effective collisions** taking place in the reaction
- **rate of reaction increases**.

(ii) Suggest why car manufacturers are required to fit catalytic converters to car exhaust systems.

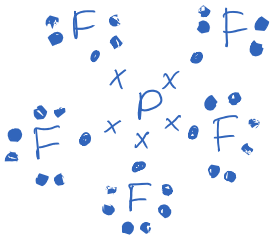
Catalytic converters can **remove air pollutants such as CO and NO_2** and convert them into **harmless gases such** as CO_2 and N_2.

CO will bind with haemoglobin thus preventing the transport of oxygen in humans, or that NO_2 forms photochemical smog or acid rain.

6 **(a)** Phosphorus reacts with fluorine to form PF_3 and PF_5.

(i) Draw the dot-and-cross diagram for one molecule of PF_5. Show only the outer shell electrons.

[1]



(ii) Explain why the P–F bond is polar.

…….. [1]

F is more electronegative than P / There is a **difference in electronegativity** between P and F.

(iii) Predict whether or not a molecule of PF_5 is polar. Explain your answer.

……

…….. [1]

Non-polar.
The **dipole moments cancel out** each other.
(specimen paper accepts the molecule is symmetrical)

(iv) Nitrogen reacts with fluorine to form NF_3 only.

Explain why PF_5 exists whereas NF_5 does not exist.

……

…….. [1]

P is a period 3 element which has **energetically accessible vacant 3d orbitals** for **expansion of octet/ to accommodate more than 8 electrons** whereas N is a period 2 element which does not have energetically accessible (3d) orbitals.

(b) The reaction between sulfur dioxide and oxygen is a reversible reaction and can be described as being in dynamic equilibrium.

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

A 2-dm^3 reaction vessel containing 0.80 mol of SO_2, 0.30 mol of O_2 and 1.40 mol of SO_3 is allowed to reach equilibrium at a constant temperature of 1000 K. It was determined that 0.42 mol of SO_2 is present at equilibrium.

(i) State the meaning of the term *dynamic equilibrium*.

……

…….. [1]

Dynamic equilibrium is a state of reversible reaction in which the **forward and backward reaction occurs at the same rate** such that the **concentration of reactants and products remain constant**.

(i) Use the information given to complete Table 6.1.

Table 6.1

	SO_2	O_2	SO_3
Initial amount/ mol			
Equilibrium amount/ mol			

[2]

	SO_2	O_2	SO_3
Initial amount/ mol	0.80	0.30	1.40
Equilibrium amount/ mol	0.43	0.30 – ½ (0.37) = 0.115	1.40 + 0.37 = 1.77

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

[1]

$K_c = \frac{[SO_3]^2}{[SO_2]^2\,[O_2]}$

(iii) Calculate the value of K_c. State the units of K_c.

[2]

$K_c = \frac{(\frac{1.77}{2})^2}{(\frac{0.43}{2})^2\,(\frac{0.115}{2})} = \frac{0.7832}{0.002658} = 294.7 = 295$

Units for K_c: $mol^{-1}\ dm^3$

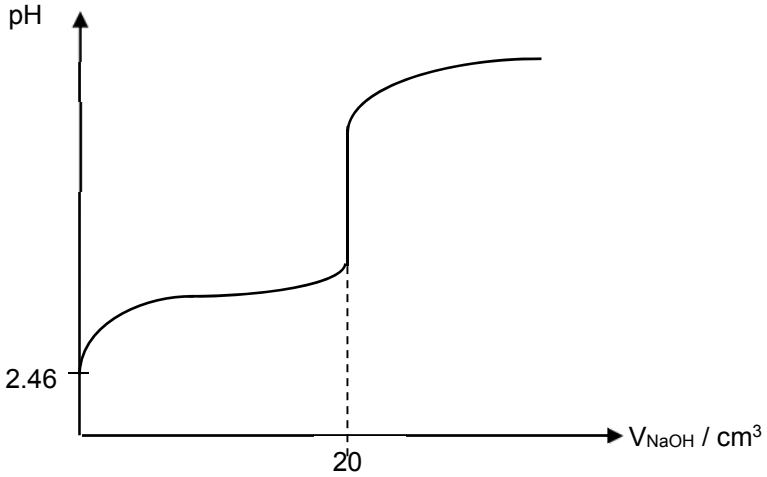
(c) (i) State the difference between a weak acid and a strong acid

……

…….. [1]

Weak acid undergoes **partially dissociation** in water to form H^+ ions whereas strong acid undergoes **complete dissociation** in water to form H^+ ions.

20.0 cm^3 of 0.01 mol dm^{-3} propanoic acid, CH_3CH_2COOH was titrated against 0.01 mol dm^{-3} aqueous sodium hydroxide.



The initial pH of propanoic acid is 2.46.

(ii) Calculate the initial concentration of hydrogen ions before the titration.

[1]

$[H^+] = 10^{-2.46}$
$= 3.47 \times 10^{-3}$ mol dm^{-3}

During the addition of the first 20 cm^3 of sodium hydroxide the mixture is behaving as a buffer.

(ii) Explain how the shape of the graph show this.

……

…….. [1]

The graph is **relatively flat/ gentle gradient** between 0 to 20 cm^3, indicating that **there is little change/increase in pH** during the addition of NaOH.

(iii) Identify the two species present in the mixture that constitutes to it behaving as a buffer.

…….. [1]

CH_3CH_2COOH and $CH_3CH_2COO^-$ / CH_3CH_2COONa

(d) Polyvinyl acetate, PVAc, is a useful adhesive for gluing together articles made from wood, paper or cardboard. The diagram shows a section (not a repeat unit) of the PVAc.

PVAc

(i) What type of polymerisation made this polymer?

…….. [1]
addition polymerisation

(ii) PVAc is made from monomer **X**. Draw the structure of the **X**.

[1]

(iii) PVAc can be converted to polyvinyl alcohol, PVA.

Draw a section of PVA containing at least 2 repeat units and suggest the reagents and conditions needed to make PVA from PVAc in the laboratory.

Section of PVA:

Reagents and conditions: ……..
[2]

NaOH(aq), heat or H_2SO_4(aq), heat

(e) The diagrams below are molecular representations of two types of plastics – thermoplastics and thermosets.

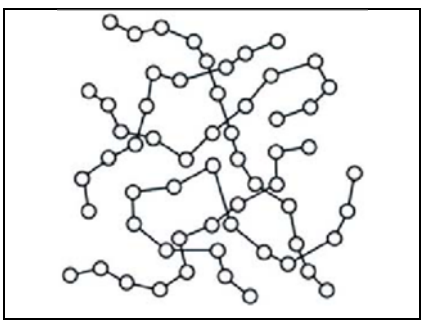


Diagram **A**

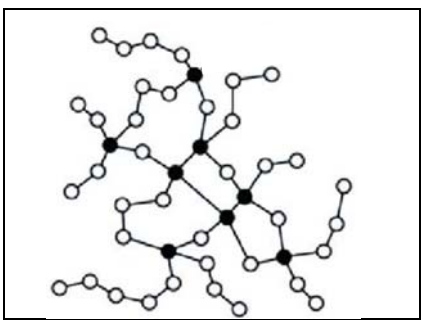


Diagram **B**

(i) State and explain which diagram could be the representation for thermosets.

……

…….. [1]

Diagram B. There is **extensive cross-linking** present between the polymer chains.

(ii) State a difference in physical properties between thermoplastics and thermosets.

……

…….. [1]

Thermoplastics **soften on heating** (and harden on cooling) whereas thermosets **cannot be soften on heating**.

[Total: 20m]