ANDERSON SERANGOON JUNIOR COLLEGE

2020 JC 2 PRELIMINARY EXAMINATION

H1 CHEMISTRY **8873/01**

Paper 1 Multiple Choice **23 September 2020**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and class on the Answer Sheet in the spaces provided.

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.

Multiple Choice Answer Sheet

Write your name, class and NRIC / FIN number, **including** the reference letter.

Shade the NRIC / FIN number.

Exam Title: JC2 Preliminary Exam

Exam Details: H1 Chemistry / Paper 1

Date: 23/09/2020

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

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

The table shows the successive ionisation energy (I.E.) values for element **A** and **B**.

	I.E. / kJ mol^{-1}							
element	1st	2nd	3rd	4th	5th	6th	7th	8th
A	577	1820	2740	11600	14842	18379	23326	27464
B	1313	3389	5300	7469	10990	13326	71334	84078

Which statement is correct?

A The valence electrons of **A** are found in an electronic shell with principal quantum number higher than that of **B.**

B The successive ionisation energies show an increasing trend due to an increase in nuclear charge.

C Element **B** belongs to Group 14.

D Element **A** is a gas at room temperature.

2 Beams of charged particles are deflected by an electric field.

In an experiment, protons are deflected by an angle of +25°. In another experiment, under identical conditions, particle **C** is deflected by an angle of –5°.

What could be the composition of particle **C**?

	protons	neutrons	electrons
A	17	18	18
B	7	8	10
C	3	6	2
D	5	5	3

3 Which of the following species has the most number of unpaired electrons?

A Cr **B** Ni **C** Ca^{2+} **D** Co^{3+}

4 Propyne, C_3H_4, has the following structure, $HC{\equiv}CCH_3$.

Which of the following correctly describes the number of σ and π bonds present in a molecule of propyne?

	σ	π
A	1	3
B	2	2
C	5	3
D	6	2

5 In which pair of compounds does the first molecule has a net dipole but the second molecule has no net dipole?

A SF_6 and BCl_3

B SO_3 and NH_3

C NH_3 and $AlCl_3$

D H_2O and CO

6 A crystalline solid is a solid material whose constituent particles are arranged in a highly ordered microscopic structure, forming a crystal lattice that extends in all directions.

What are the particles present in each lattice?

	silver	iodine	silver iodide	water
A	cations	molecules	ions	molecules
B	atoms	molecules	atoms	ions
C	cations	atoms	atoms	molecules
D	atoms	atoms	ions	atoms

7 Which of the following statements about ionic and covalent compounds is true?

A Ionic compounds are generally soluble in non–polar solvents.

B Ionic compounds always exhibit higher melting points than covalent compounds.

C All ionic compounds cannot have covalent bonds within the ions.

D Some covalent compounds can conduct electricity under appropriate conditions.

8 Which statements about the structure of ice are correct?

1 Ice has a giant covalent structure.
2 The open structure of ice causes ice to be less dense than water.
3 Ice is able to float in water due to hydrogen bonding.

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

9 Which statement, regarding the liquefaction of a gas, is true?

A Gases can only be converted to liquids at their corresponding boiling temperatures.

B Gases under intense pressure, can be converted to liquid at a lower temperature as compared to the boiling point.

C Nitrogen gas can never be converted into a liquid due to its low boiling point.

D It is harder to liquefy carbon dioxide than nitrogen.

10 The enthalpy change of fusion of a solid is defined as the amount of energy, in J or kJ, required to melt one mole of a solid at its melting point.

The table shows the enthalpy change of fusion of four successive elements, *W* to *Z*, in the third period (sodium to argon) of the Periodic Table.

element	*W*	*X*	*Y*	*Z*
enthalpy change of fusion / kJ mol^{-1}	10.8	46.4	0.6	1.4

Which sequence of elements is represented by *W* to *Z*?

	W	*X*	*Y*	*Z*
A	*Al*	Si	P	S
B	Na	Mg	*Al*	Si
C	P	S	*Cl*	Ar
D	Si	P	S	*Cl*

11 The percentage by mass of water in a hydrated iron(III) chloride salt is 35.7%.

What is the empirical formula of the hydrated salt?

A $FeCl_3.3H_2O$ **B** $FeCl_3.4H_2O$ **C** $FeCl_3.5H_2O$ **D** $FeCl_3.6H_2O$

12 The relative atomic mass of chlorine, which consist of the isotopes ^{35}Cl and ^{37}Cl, is 35.45.

What is the percentage of ^{35}Cl in the isotopic mixture?

A 87.5% **B** 77.5% **C** 22.5% **D** 12.5%

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

How many atoms are present in 1 cm^3 of argon gas under room temperature and pressure conditions?

A $\dfrac{24000}{6.02\times10^{23}}$ **B** $\dfrac{6.02\times10^{23}}{24000}$

C $\dfrac{6.02\times10^{23}}{24}$ **D** $\dfrac{6.02\times10^{23}}{39.9}$

14 Which of the equations correctly defines the standard enthalpy change of formation of a compound?

1 $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

2 $H_2(g) + O_2(l) \rightarrow H_2O_2(l)$

3 $6H_2(g) + P_4(s) + 8O_2(g) \rightarrow 4H_3PO_4(l)$

4 $C(s) + \frac{5}{2}H_2(g) + \frac{1}{2}N_2(g) \rightarrow CH_3NH_2(g)$

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

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

What is the enthalpy change of reaction for this reaction?

$$2H_2O_2(g) \rightarrow 2H_2O(g) + O_2(g)$$

A 796 kJ mol^{-1} **B** 346 kJ mol^{-1}

C −1116 kJ mol^{-1} **D** −196 kJ mol^{-1}

16 The rate of decomposition of the diazonium cation,

$$C_6H_5N_2^+ + H_2O \rightarrow C_6H_5OH + H^+ + N_2$$

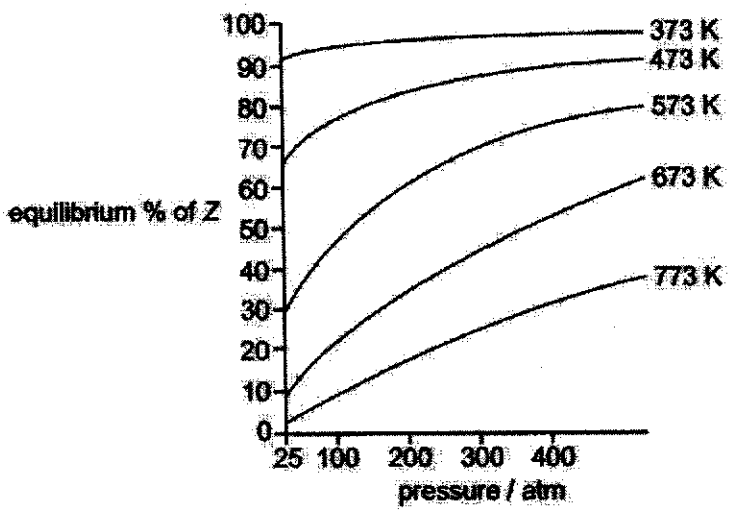
can be followed by measuring the time taken for the same volume of nitrogen to be produced from a range of diazonium cation concentrations.

To find the order of reaction with respect to the diazonium cation, which would be the most suitable graph to plot using the data?

A $[C_6H_5N_2^+]$ against time **B** $[C_6H_5N_2^+]$ against 1/time

C Volume of N_2 against time **D** Volume of N_2 against 1/time

17 The equilibrium percentage of **Z** varies according to varying pressures and temperatures as shown in the graphs.



Which row in the table shows the correct information about the equilibrium?

	equilibrium reaction	sign of ΔH for the forward reaction
A	**Y**(g) + **Z**(g) ⇌ 3**X**(g)	positive
B	**X**(g) + **Y**(g) ⇌ 2**Z**(g)	positive
C	**X**(g) + **Z**(g) ⇌ **Y**(g)	negative
D	2**Y**(g) + **X**(g) ⇌ 4**Z**(g)	negative

18 In which reaction is the first reactant **not** acting as a Bronsted–Lowry base?

A $\underline{NH_3} + CH_3Br \rightarrow CH_3NH_3^+ + Br^-$

B $\underline{OH^-} + HSO_4^- \rightarrow H_2O + SO_4^{2-}$

C $\underline{CH_3OH} + HClO_4 \rightarrow CH_3OH_2^+ + ClO_4^-$

D $\underline{HNO_3} + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$

19 Values for the ionic product of water, K_w, at two different temperatures are given below.

temperature / °C	K_w / mol^2 dm^{-6}
25	1.00×10^{-14}
30	1.44×10^{-14}

Which of the following statements is false?

A The dissociation of water is an endothermic process.

B pH is less than 7 at 30 °C.

C $[OH^-]$ is 1.00×10^{-7} mol dm^{-3} at 25 °C.

D Water is alkaline at 30 °C.

20 Which of the following statements regarding the buffer system in the human blood circulatory system is **not** true?

1 The buffer is a mixture comprising HCO_3^- and CO_3^{2-}.

2 The buffer is only useful against small amounts of acid added.

3 CO_2 formed in tissue cells during respiration is responsible for one of the buffer components.

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

21 The table shows some data on two acid–base indicators.

indicator	pH range of colour change	colour change	
		acid	alkali
alizarin yellow	10.1–13.0	yellow	orange
phenol red	6.8–8.5	yellow	red

Which conclusion can be drawn about a solution in which alizarin yellow is yellow and phenol red is violet?

A It is strongly acidic.

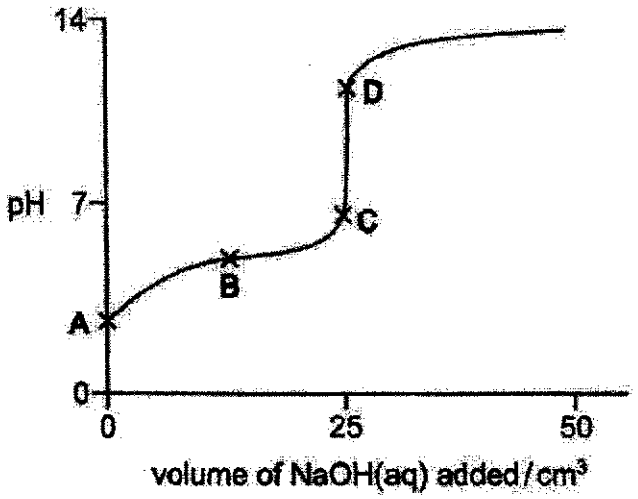
B It is weakly acidic.

C It is neutral.

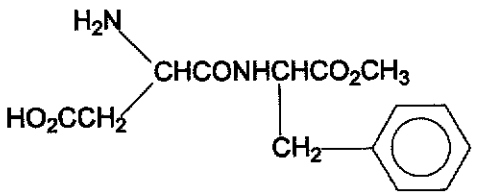
D It is weakly alkaline.

22 The diagram shows the change in pH when 50 cm^3 of aqueous sodium hydroxide is added to 25 cm^3 of propanoic acid of the same concentration.

At which point would the solution be a mixture of propanoic acid and sodium propanoate?



23 *Aspartame* is a common artificial sweetener that has the structure shown below:



Aspartame

Which of the following functional groups are present in *aspartame*?

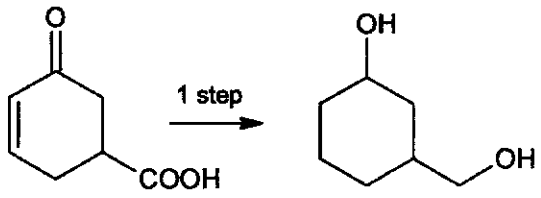
A alcohol, amide, ketone

B alcohol, carboxylic acid, ester

C amide, carboxylic acid, ester

D amine, carboxylic acid, ketone

24 Which of the following reagents and conditions can be used for the reaction shown below?



A $H_2(g)$, Pt catalyst

B $NaBH_4$ in ethanol

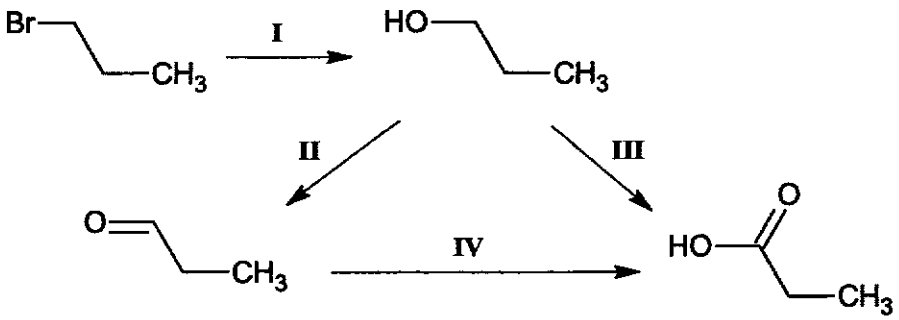
C $LiAlH_4$ in dry ether

D None of the above

25 How many non–cyclic isomers, including cis–trans isomers, are there with molecular formula C_5H_{10}?

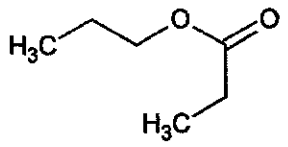
A 8 **B** 7 **C** 6 **D** 5

26 Which of the following lists the correct type of reaction for steps **I**, **II**, **III** and **IV**?



	Step I	Step II	Step III	Step IV
A	substitution	condensation	substitution	condensation
B	hydrolysis	elimination	condensation	addition
C	addition	reduction	addition	elimination
D	substitution	oxidation	oxidation	oxidation

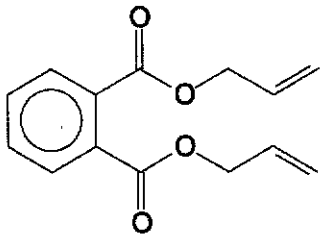
27 What is the IUPAC name of the organic compound shown below?



A Butyl butanoate **B** Ethyl butanoate

C Propyl ethanoate **D** Propyl propanoate

28 Which of the following statements are true about the polymer formed from dially phthalate?



dially phthalate

1 It is a condensation polymer.

2 It can form cross–links through the ester groups.

3 It cannot be recycled.

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

29 Which statements are **incorrect** about addition polymers polyethene and polyvinylchloride?

1 On complete combustion, both polymers produces carbon dioxide and water only.

2 Both polymers are not biodegradable.

3 Both polymers releases water as a by–product of polymerization.

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

30 Four students recorded some observations about polyesters and attempted to explain them.

Which student is correct?

	Observation	Reason
A	All polyesters are made from two different monomers.	Ester linkages formed between the alcohol functional group of one of the monomers and the carboxylic acid functional group of the other monomer.
B	Polyesters are biodegradable.	The ester linkages are easily broken using water.
C	Polyester bottles cannot be left in out in the open.	The high temperature from the sun provides sufficient energy to break the covalent bonds in the polyester.
D	Polyester fabric are usually wrinkle–free.	Polyester chains do not readily form hydrogen bonds with each other.

ANDERSON SERANGOON JUNIOR COLLEGE

2020 PRELIMINARY EXAMINATION

NAME:_____ ( ) **CLASS:** 20 / ___

CHEMISTRY **8873/02**

Paper 2 Structured Questions **15 September 2020**

Candidates answer on the Question Paper. **2 hours**

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST
Write your name, class and register number 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.
A Data Booklet is provided.

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

For Examiner's Use				
Section A	1	/ 11	Paper 2 Total	/ 80
	2	/ 20	Paper 1	/ 30
	3	/ 17	Percentage Overall	
	4	/ 12	Grade	
Section B	5	/ 20	Please circle question number of question attempted in Section B	
	6	/ 20		

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

Section A

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

1 **(a)** Fig. 1.1 shows an article which appeared in the Manchester Gazette back in 2008.

Sodium Drum Blaze Scare

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

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

Fig. 1.1

(i) Explain why sodium is normally stored under oil.

.....[1]

(ii) Write an equation, with state symbols, for the reaction of sodium with water.

.....[1]

(iii) Explain why potassium would react more violently with water than sodium.

.....

.....

.....[2]

(iv) Hence, state the trend of the reducing power of the metals down Group 1.

.....[1]

(b) Sodium–24 is one of the most important sodium isotopes. It is radioactive and decays with a half–life of 15 hour. ^{24}Na decays to ^{24}Mg by emitting an electron and two gamma rays.

(i) State the number of subatomic particles of a ^{24}Na atom.

.....[1]

(ii) State which atom, ^{24}Na or ^{24}Mg, would have a larger atomic radius. Explain your answer.

.....

.....

.....[2]

(iii) A blood plasma sample of a patient was analysed to find the amount of ^{24}Na present. After some time, the same sample was analysed again and only 10% of ^{24}Na was left in the plasma.

Estimate the time elapsed between the two sample analysis.

[1]

(c) Some observations of experiments involving Period 3 oxides were recorded in Table 1.1.

Table 1.1

Oxide	Observations
A	dissolves completely in water, turns litmus blue.
B	reacts with both dilute NaOH and dilute HC*l*.
C	insoluble in both dilute NaOH and dilute HC*l*.

(i) Identify oxides **A**, **B** and **C**.

A: ..... **B**: ..... **C**: ..... [1]

Oxides **B** is mixed into an aqueous solution of oxide **A**.

(ii) State the type of reaction that will occur.

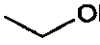
.....[1]

[Total: 11]

2 Organic compounds are molecules that contain carbon atoms covalently bonded to hydrogen atoms.

(a) The boiling points of two organic compounds are shown in Table 2.1.

Table 2.1

compound	formula	M_r	boiling point / °C
ethanol		46.0	78
ethylamine		45.0	20

(i) Suggest an explanation for the difference in boiling points.

.....

.....

.....[1]

(ii) Bromoethane can be converted to ethanol. State the type of reaction and suggest the reagents and condition required.

.....

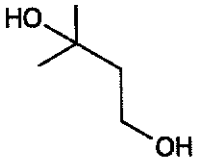
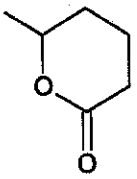
.....[2]

(b) **(i)** Draw the structure of the major product formed when 2–methylbut–2–ene, $(CH_3)_2C{=}CHCH_3$, undergoes addition reaction with water.

[1]

(ii) Complete Table 2.2 with the skeletal structure of the product formed when the respective organic compounds shown are reacted with hot acidified potassium manganate(VII).

Table 2.2

[2]

(c) Diazene, N_2H_2, can be isolated as two isomers at low temperatures.

Using the usual valencies of hydrogen and nitrogen, draw a structure of N_2H_2 showing clearly the electrons pairs around the nitrogen atoms.

Hence, give an account for the molecule shape and bond angle about each central atom using the principles of the Valence Shell Electron Pair Repulsion theory.

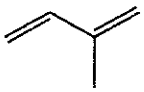
.....

.....

.....

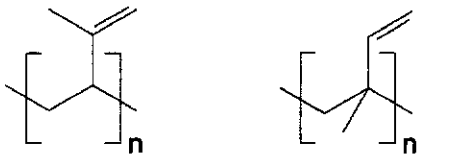
.....[3]

(d) Isoprene, or 2–methyl–1,3–butadiene, is a colourless volatile liquid produced by many plants and animals. When polymerised, it forms the main component of natural rubber. C. G. Williams first discovered it in 1860 after obtaining it from thermal decomposition of natural rubber. About 95% of isoprene production today goes to the production of a synthetic version of natural rubber.



isoprene

Isoprene can form four different polyisoprene polymer chains. Fig. 2.1 shows two of the four possible polymer chains that can be synthesised.



3,4–polyisoprene 1,2–polyisoprene

Fig. 2.1

Materials made with 3,4–polyisoprene and 1,2–polyisoprene are found to have very high tensile strength with very little flexibility. These materials do not soften upon heating, but chars instead when heated beyond a certain point.

(i) State the type of polymerisation that produces these polyisoprene polymers.

.....[1]

(ii) Predict whether 3,4–polyisoprene and 1,2–polyisoprene are thermosetting or thermoplastic polymers.

Explain your answer using the information in the question **and** your knowledge of the structure and bonding in polymers.

.....

.....

.....[2]

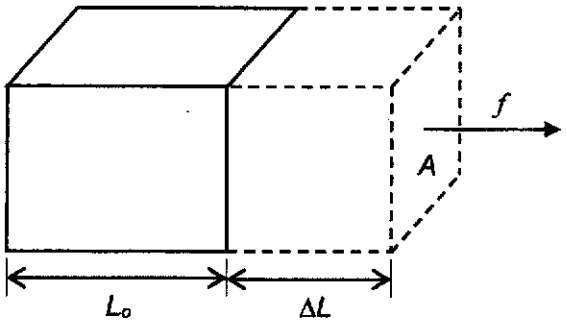
The two other polyisoprene polymers that can be synthesised from isoprene are cis–1,4–polyisoprene and trans–1,4–polyisoprene.

(iii) Draw the repeat units of both cis–1,4–polyisoprene and trans–1,4–polyisoprene.

[2]

(e) Mechanical properties of polymers can be analysed to determine their suitability for different purposes.

A polymer elongates when a tension force is applied, and two physical properties, tensile stress and strain, can be evaluated for any given polymer as shown in Fig. 2.2.



tensile stress

$$\sigma_t = \frac{f}{A}$$

where f is the force along the axis of deformation and A is the area where the force has been applied.

strain

$$\varepsilon = \frac{\Delta L}{L_o}$$

where ΔL is the change in length and L_o is the original length.

Fig. 2.2

Tensile stress can be further evaluated into tensile strength and yield strength, where:

- tensile strength is the maximum stress at point of breaking, and
- yield strength is the point at which the polymer is still intact, but unable to return to its original shape or dimensions.

Both tensile stress and strain can be correlated into a simple linear equation:

$$\sigma_t = E\,\varepsilon$$

where the proportionality constant, E, is called Young's Modulus.

(i) Suggest how the value of Young's Modulus correlates to the physical property of rigidity of a polymer.

.....

.....[1]

Low–density polyethylene, LDPE, is a thermoplastic commonly used to manufacture plastic carrier bags.

They are light–weight and are able to withstand a considerable amount of stress before deforming. However, the carrier bag can still be used whilst deformed, being stretched to its limits before ultimately breaking into two.

(ii) Draw a diagram to show the highly branched structure of LDPE.

[1]

(iii) With reference to your diagram drawn in **(e)(ii)**, suggest why LDPE is able to be stretched before breaking at the point of fracture. Explain your answer.

.....

.....

.....[1]

Table 2.3 shows the common uses of three other polymers.

Table 2.3

Polymer	Common Uses
polycarbonate	bulletproof glass
high–density polyethylene (HDPE)	bowls, buckets, detergent bottles
cis–1,4–polyisoprene	elastic/rubber bands, gloves, car tyres

The three polymers were also tested for their Young's Modulus, *E*, and the data collected were translated into a graph plot shown in Fig. 2.3.

It was noted that when a polymer reaches its yield strength (at yield point), it will start to deform without breaking thus allowing the polymer to be moulded and when the polymer reaches its tensile strength (at fracture), it will break.

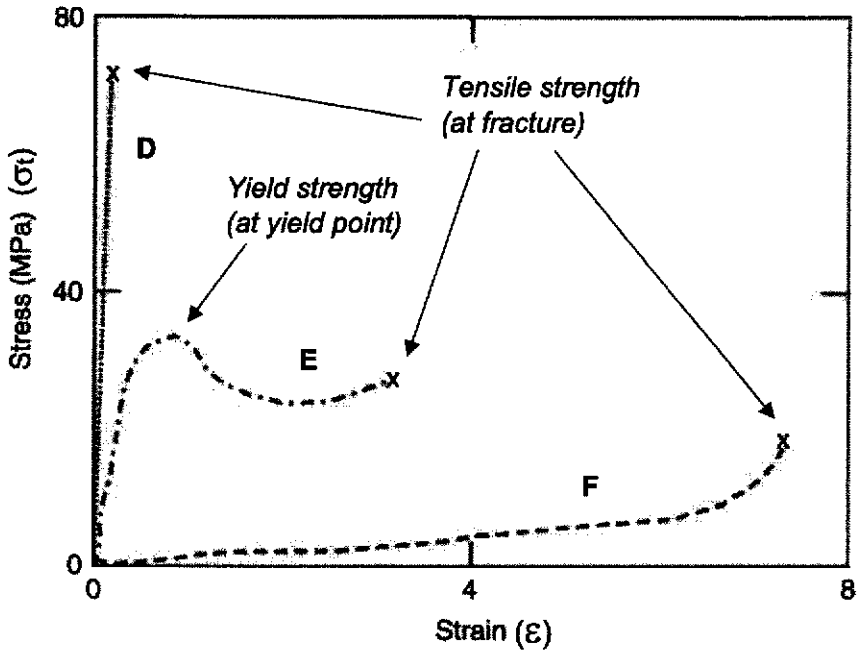


Fig. 2.3

(iv) Using the information provided, identify polymers **D**, **E** and **F** respectively.

D .....

E .....

F .....

[3]

[Total: 20]

Question 3 starts on the next page.

3 (a) *Reaction 1* shows how hydrogen peroxide reacts with acidified potassium iodide, where the rate can be studied by varying concentration of the reactants.

$$2H^+ + 2I^- + H_2O_2 \rightarrow I_2 + 2H_2O \qquad \textit{reaction 1}$$

The data collected are listed in Table 3.1.

Table 3.1

run	initial $[H_2O_2]$ / mol dm^{-3}	initial $[I^-]$ / mol dm^{-3}	pH	time taken for iodine to appear / s	relative rate
1	0.010	0.10	1	16.0	
2	0.030	0.10	1	5.3	
3	0.015	0.10	2	10.0	
4	0.010	0.40	1	4.0	

(i) Given that the rate is proportional to $\frac{1}{\text{time taken for iodine to appear}}$ for the above runs, fill in the empty column in Table 3.1 and deduce the order of reactions with respect to each reactant of reaction 1. Explain your answer.

[4]

(ii) Hence, write the rate equation of the reaction, stating the units of the rate constant.

.....

.....[2]

(iii) Sketch the graph of $[H_2O_2]$ against time for this reaction when $[I^-]$ and $[H^+]$ are in large excess.

[1]

(iv) On the same axes as **(a)(iii)**, sketch another graph of $[H_2O_2]$ against time for this reaction when $[I^-]$ and $[H^+]$ are in large excess, but the initial concentration of $[H_2O_2]$ is now halved. Explain your answer.

.....

.....

.....

.....[2]

(b) Hydrogen peroxide is unstable and slowly decomposes in the presence of light or catalyst as shown in *reaction 2*. Due to its instability, hydrogen peroxide is typically stored in a dark coloured bottle.

$$H_2O_2(aq) \rightarrow \frac{1}{2}O_2(g) + H_2O(l) \qquad \textit{reaction 2}$$

A bottle of household cleaner, containing a 3% by mass of hydrogen peroxide was used to investigate the enthalpy change of decomposition of hydrogen peroxide.

All relevant data in the experiment were recorded in Table 3.2.

Table 3.2

Initial temperature	21.9 °C
Final temperature	39.1 °C
Volume of household cleaner used	60 cm^3
Specific heat capacity of cleaner	4.18 $J\ K^{-1}\ g^{-1}$
Heat capacity of the Styrofoam cup	5 $J\ K^{-1}$

(i) Calculate the concentration of hydrogen peroxide in the household cleaner, in mol dm^{-3}. Assume density of the cleaner is 1.0 g cm^{-3}.

[1]

(ii) By considering the heat capacities of both the cleaner and Styrofoam cup, show that the heat released by the decomposition of hydrogen peroxide is 4400 J.

[2]

(iii) Hence, calculate the enthalpy change of decomposition of hydrogen peroxide shown in *reaction 2*.

[1]

(iv) The enthalpy change of formation of aqueous hydrogen peroxide can be determined by using the energy cycle shown in Fig. 3.1.

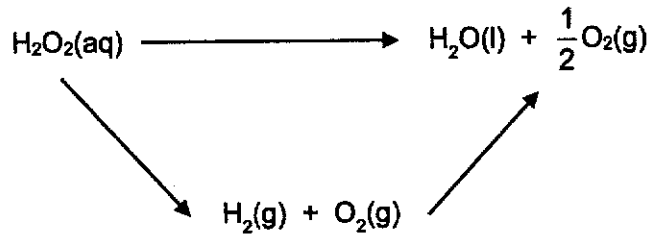


Fig. 3.1

Given that the standard enthalpy change of combustion of hydrogen is -285.8 kJ mol^{-1}, use Fig. 3.1 and your answer from **(b)(iii)** to calculate the standard enthalpy change of formation of aqueous hydrogen peroxide.

[2]

(v) The decomposition of hydrogen peroxide is proposed to be a first order reaction. State what the effect an increase in temperature would have on the rate constant of the experiment described in **(b)**. Explain your answer.

.....

.....[2]

[Total: 17]

4 The Haber process is an artificial nitrogen fixation process and is the main industrial procedure for the production of ammonia today.

The process converts atmospheric nitrogen to ammonia by a reaction with hydrogen using a metal catalyst under high temperatures and pressures:

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

(a) (i) State *Le Chatelier's Principle*.

.....

.....

.....[1]

(ii) State the optimum industrial conditions for the production of ammonia via the Haber process. Explain the rationale behind these conditions.

.....

.....

.....

.....

.....

.....

.....[2]

(iii) Nitrogen and hydrogen gas were added into a 1 dm^3 reaction vessel, in a 1:1 mole ratio.
The reaction mixture was allowed to reach equilibrium at constant temperature.
It was observed that the equilibrium amount of nitrogen gas was 0.894 mol.

Calculate the equilibrium constant, K_c, of the reaction, stating its units.

[2]

(iv) State the impact an increase in temperature would have on the K_c. Explain your answer.

.....

.....[1]

(b) Draw a Boltzmann distribution for the Haber process and explain the effect of how addition of catalyst would have on the rate of reaction.

.....

.....

.....

.....[3]

(c) (i) Unlike ammonia, calcium hydroxide is a strong base that dissociates completely when dissolved in water.

Calculate the pH of 0.016 mol dm^{-3} of calcium hydroxide.

[2]

(ii) Write an equation to show how a mixture of ammonia and ammonium chloride is able to resist pH change when a few drops of calcium hydroxide is added.

.....[1]

[Total: 12]

Section B

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

5 **(a)** **(i)** Sodium chlorate(I) is an inorganic compound with the formula NaC*l*O. It is a white, hygroscopic, crystalline solid.

Suggest why sodium chlorate(I) dissolves in water.

.....

.....[1]

(ii) Sodium chlorate(I) can be produced by reacting chlorine gas with sodium hydroxide. In the process, sodium chloride is produced as a by–product.

Write a balanced chemical equation for the reaction that occurred.

.....[1]

(iii) Using your equation in **(a)(ii)**, calculate the oxidation numbers of chlorine in all chlorine containing compounds.

Hence, suggest what is so unique about the reaction.

.....

.....[2]

(b) Chlorate(I) decomposes under high temperature to form chlorate(V) ions, ClO_3^-, and chloride ions. Use of chlorine dioxide in water treatment plants produces chlorate(V) ions.
As an overexposure of chlorate(V) ions may lead to multiple organ failure, a chemist analysed a 250 cm^3 sample of tap water. He determines the concentration of chlorate(V) present in the tap water by titrating a 25 cm^3 portion against a standard iron(II) solution under acidic conditions.

$$10Fe^{2+} + 2ClO_3^- + 12H^+ \rightarrow 10Fe^{3+} + Cl_2 + 6H_2O$$

It was found that exactly 14.50 cm^3 of 0.00035 mol dm^{-3} acidified iron(II) solution was required for the reaction.

(i) Calculate the number of moles of ClO_3^- in 250 cm^3 of tap water. Give your answer to three significant figures.

[2]

(ii) Calculate the concentration, in g dm^{-3}, of ClO_3^- in the water.

[2]

(iii) Draw a 'dot–and–cross' diagram showing the bonding of the chlorate(V) ion, ClO_3^-.

[1]

(c) Table 5.1 shows some information of sodium chloride and aluminium chloride.

Table 5.1

	melting point / °C	molar mass / g mol^{-1}
sodium chloride	801	58.5
aluminium chloride	192	133.5

(i) Explain the difference in the melting points.

.....

.....

.....

.....

.....[2]

(ii) At lower temperatures, the numerical value of the molar mass of gaseous aluminium chloride was found to be 267.0.

With the aid of a diagram, give an account for this phenomenon observed. Explain your answer.

.....

.....[2]

(iii) State what is observed when a **limited** amount of water is added to a test tube containing solid aluminium chloride. Write a chemical equation to show the reaction that took place.

.....

.....[2]

(iv) Besides the properties mentioned in Table 5.1, **(c)(ii)** and **(c)(iii)**, suggest two differences with regards to the chemical properties of sodium chloride and aluminium chloride. You have to include relevant chemical equations in your answer.

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.....[5]

[Total: 20]

6 (a) (i) 10 cm^3 of a hydrocarbon, C_xH_y, was exploded with 100 cm^3 of oxygen gas and there was a contraction of 30 cm^3 of the total gas volume. The gases was then bubbled through aqueous sodium hydroxide, causing the volume to further decrease by 40 cm^3.

Given that all gaseous volumes were measured under room temperature and pressure conditions, determine the volume of oxygen gas required for C_xH_y to undergo complete combustion.

[1]

(ii) Hence, identify C_xH_y.

[2]

(b) **(i)** Define the term *constitutional isomerism*.

.....

.....[1]

(ii) Draw the structures of all non–cyclic constitutional isomers of C_4H_8.

[2]

(iii) Suggest if any of these isomers are able to exhibit cis–trans isomerism. Explain your answer.

.....

.....

.....[2]

(c) Sodium chloride, magnesium chloride and silicon chloride are all able to dissolve in water.

Describe and explain the reactions of these chlorides with water including relevant equations, clearly stating the pH of the respective resultant solutions.

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.....[5]

(d) **(i)** State the trend of the relative oxidising ability of halogens down Group 17. Explain your answer.

.....

.....

.....

.....[2]

(ii) Table 6.1 shows the observations made when halogens X_2, Y_2 and Z_2 were reacted with their corresponding halides.

Table 6.1

	X^-	Y^-	Z^-
X_2		Orange solution observed	Brown solution observed
Y_2	No observation		Brown solution observed
Z_2	No observation	No observation	

Suggest the identities of X_2, Y_2 and Z_2.

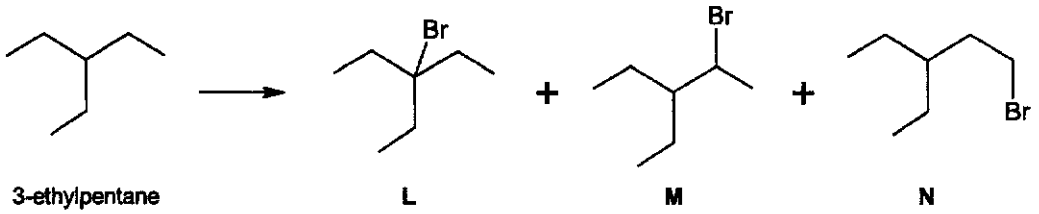
X_2: ..... Y_2: ..... Z_2: ..... [1]

(iii) The ease of breaking the covalent bond of a diatomic halogen molecule increases from chlorine to iodine. However, fluorine does not follow the same trend. Suggest a reason for the anomaly.

.....

.....[1]

(e) Fig. 5.1 shows the three possible monobromoalkanes that can be formed from 3–ethylpentane.



3-ethylpentane **L** **M** **N**

(i) State the reagents and conditions for the production of **L**, **M** and **N** from 3–ethylpentane.

.....[1]

(ii) Predict the relative proportions of **L**, **M** and **N** that are likely to be produced from 3–ethylpentane. Explain your answer.

.....

.....

.....

.....

.....[2]

[Total: 20]

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

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

The table shows the successive ionisation energy (I.E.) values for element **A** and **B**.

	I.E. / kJ mol^{-1}							
Element	1st	2nd	3rd	4th	5th	6th	7th	8th
A	577	1820	2740	11600	14842	18379	23326	27464
B	1313	3389	5300	7469	10990	13326	71334	84078

Which statement is correct?

	A	The valence electrons of **A** are found in an electronic shell with principal quantum number higher than that of **B**.
	B	The successive ionisation energies show an increasing trend due to an increase in nuclear charge.
	C	Element **B** belongs to Group 14.
	D	Element **A** is a gas at room temperature.

[redacted]

2 Beams of charged particles are deflected by an electric field.

In an experiment, protons are deflected by an angle of +25°. In another experiment, under identical conditions, particle **C** is deflected by an angle of –5°.

What could be the composition of particle **C**?

	protons	neutrons	electrons	
A	17	18	18	
B	7	8	10	
C	3	6	2	
D	5	5	3	

[redacted]

3 Which one of the following species has the most number of unpaired electrons?

A Cr **B** Ni **C** Ca^{2+} **D** Co^{3+}

[redacted]

4 Propyne, C_3H_4, has the following structure, $HC{\equiv}CCH_3$.

Which of the following correctly describes the number of σ and π bonds present in a molecule of propyne?

	σ	π		
A	1	3		
B	2	2		
C	5	3		
D	6	2		

[redacted]

5 In which pairs of compounds does the first molecule has a net dipole but the second molecule has no net dipole?

A SF_6 and BCl_3 **B** SO_3 and NH_3

C NH_3 and $AlCl_3$ **D** H_2O and CO

[redacted]

6 A crystalline solid is a solid material whose constituent particles are arranged in a highly ordered microscopic structure, forming a crystal lattice that extends in all directions.

What are the particles present in each lattice?

	Silver	Iodine	Silver Iodide	Water
A	cations	molecules	ions	molecules
B	atoms	molecules	atoms	ions
C	cations	atoms	atoms	molecules
D	atoms	atoms	ions	atoms

[redacted]

7 Which of the following statements about ionic and covalent compounds is true?

A Ionic compounds are generally soluble in non-polar solvents.

B Ionic compounds always exhibit higher melting points than covalent compounds.

C All ionic compounds cannot have covalent bonds within the ions.

D Some covalent compounds can conduct electricity under appropriate conditions.

[redacted]

8 Which statements about the structure of ice are correct?

1 Ice has a giant covalent structure.

2 The open structure of ice causes ice to be less dense than water.

3 Ice is able to float in water due to hydrogen bonding.

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

9 Which statement, regarding the liquefaction of a gas, is true?

A Gases can only be converted to liquids at their corresponding boiling temperatures.

B Gases under intense pressure, can be converted to liquid at a lower temperature as compared to the boiling point.

C Nitrogen gas can never be converted into a liquid due to its low boiling point.

D It is harder to liquefy carbon dioxide than nitrogen.

10 The enthalpy change of fusion of a solid is defined as the amount of energy, in J or kJ, required to melt one mole of a solid at its melting point.

The table shows the enthalpy change of fusion of four successive elements, *W* to *Z*, in the third period (sodium to argon) of the Periodic Table.

element	*W*	*X*	*Y*	*Z*
enthalpy change of fusion / kJ mol^{-1}	10.8	46.4	0.6	1.4

Which sequence of elements is represented by *W* to *Z*?

	W	*X*	*Y*	*Z*
A	*Al*	Si	P	S
B	Na	Mg	*Al*	Si
C	P	S	*Cl*	Ar
D	Si	P	S	*Cl*

11 The percentage by mass of water in a hydrated iron(III) chloride salt is 35.7%.

What is the empirical formula of the hydrated salt?

A $FeCl_3.3H_2O$ **B** $FeCl_3.4H_2O$ **C** $FeCl_3.5H_2O$ **D** $FeCl_3.6H_2O$

12 The relative atomic mass of chlorine, which consist of the isotopes $_{37}Cl$ and $_{35}Cl$, is 35.45.

Calculate the percentage of $_{35}Cl$ in the isotopic mixture.

A 87.5% **B** 77.5% **C** 22.5% **D** 12.5%

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

How many atoms are present in 1 cm^3 of argon gas under room conditions?

A	$\frac{24000}{6.02\times10^{23}}$	B	$\frac{6.02\times10^{23}}{24000}$
C	$\frac{6.02\times10^{23}}{24}$	D	$\frac{6.02\times10^{23}}{39.9}$

14 Which of the equations correctly defines the standard enthalpy change of formation of a compound?

1	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
2	$H_2(g) + O_2(l) \rightarrow H_2O_2(l)$
3	$6H_2(g) + P_4(s) + 8O_2(g) \rightarrow 4H_3PO_4(l)$
4	$C(s) + \frac{5}{2}H_2(g) + \frac{1}{2}N_2(g) \rightarrow CH_3NH_2(g)$

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

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

What is the enthalpy change of reaction of this reaction?

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

A	796 kJ mol^{-1}	B	346 kJ mol^{-1}
C	−1116 kJ mol^{-1}	D	−196 kJ mol^{-1}

16 The rate of decomposition of the diazonium cation,

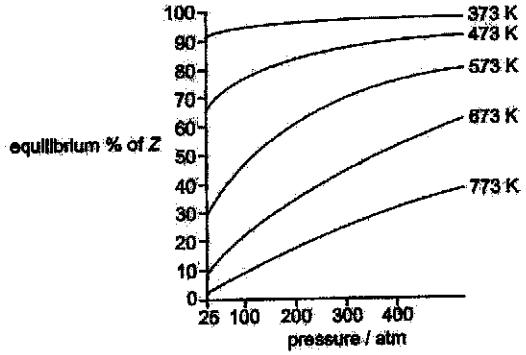
$$C_6H_5N_2^+ + H_2O \rightarrow C_6H_5OH + H^+ + N_2$$

can be followed by measuring the time taken for the same volume of nitrogen to be produced from a range of diazonium cation concentrations.

To find the order of reaction with respect to the diazonium cation, which would tbe the most suitable graph to plot using the data?

A	$[C_6H_5N_2^+]$ against time	B	$[C_6H_5N_2^+]$ against 1/time
C	Volume of N_2 against time	D	Volume of N_2 against 1/time

17 The equilibrium percentage of Z varies according to varying pressures and temperatures as shown in the graphs.



Which row in the table shows the correct information about the equilibrium?

	equilibrium reaction	sign of ΔH for the forward reaction
A	$Y(g) + Z(g) \rightleftharpoons 3X(g)$	positive
B	$X(g) + Y(g) \rightleftharpoons 2Z(g)$	positive
C	$X(g) + Z(g) \rightleftharpoons Y(g)$	negative
D	$2Y(g) + X(g) \rightleftharpoons 4Z(g)$	negative

[redacted]

18 In which reaction is the first reactant **not** acting as a Bronsted-Lowry base?

A	$\underline{NH_3} + CH_3Br \rightarrow CH_3NH_3^+ + Br^-$
B	$\underline{OH^-} + HSO_4^- \rightarrow H_2O + SO_4^{2-}$
C	$\underline{CH_3OH} + HClO_4 \rightarrow CH_3OH_2^+ + ClO_4^-$
D	$\underline{HNO_3} + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$

[redacted]

19 Values for the ionic product of water, K_w, at two different temperatures are given below.

temperature / °C	K_w / mol^2 dm^{-6}
25	1.00×10^{-14}
30	1.44×10^{-14}

Which of the following statements is false?

A	The dissociation of water is an endothermic process.
B	pH is less than 7 at 30 °C
C	$[OH^-]$ is 1.00×10^{-7} mol dm^{-3} at 25 °C
D	Water is alkaline at 30 °C.

[redacted]

20 Which of the following statements regarding the buffer system in the human blood circulatory system is **not** true?

1	The buffer is a mixture comprising HCO_3^- and CO_3^{2-}.
2	The buffer is only useful against small amounts of acid added.
3	CO_2 is formed in tissue cells during respiration is responsible for one of the buffer components.

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

[redacted]

[Turn over

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

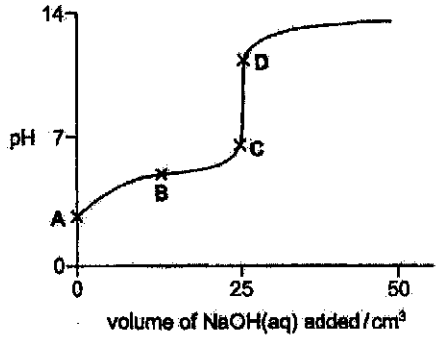
indicator	pH range of colour change	colour change	
		acid	alkali
alizarin yellow	10.1–13.0	yellow	orange
phenol red	6.8–8.5	yellow	red

Which conclusion can be drawn about a solution in which alizarin yellow is yellow and phenol red is red?

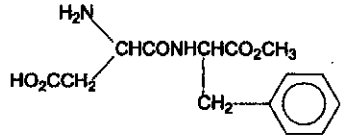
A	It is strongly acidic.
B	It is weakly acidic.
C	It is neutral.
D	It is weakly alkaline.

22 The diagram shows the change in pH when 50 cm^3 of aqueous sodium hydroxide is added to 25 cm^3 of propanoic acid of the same concentration.

At which point would the solution be a mixture of propanoic acid and sodium propanoate?



23 *Aspartame* is a common artificial sweetener that has the structure shown below:

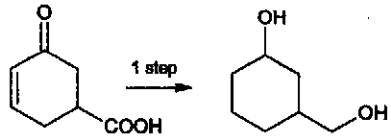


Aspartame

Which of the following functional groups are present in *aspartame*?

A	alcohol, amide, ketone		
B	alcohol, carboxylic acid, ester		
C	amide, carboxylic acid, ester		
D	amine, carboxylic acid, ketone		

24 Which of the following reagents and conditions can be used for the reaction shown below?

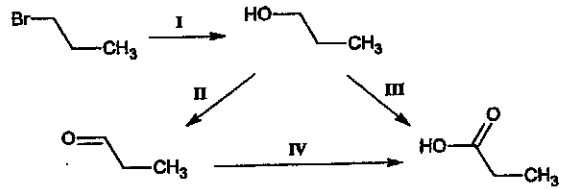


A	$H_2(g)$, Pt catalyst	**B**	$NaBH_4$ in ethanol
C	$LiAlH_4$ in dry ether	**D**	None of the above

25 How many non–cyclic isomers, including cis–trans isomers, are there with molecular formula C_5H_{10}?

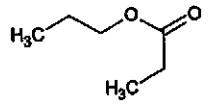
	A	8	**B**	7	**C**	6	**D**	5

26 Which of the following lists the correct type of reaction for steps **I**, **II**, **III** and **IV**?



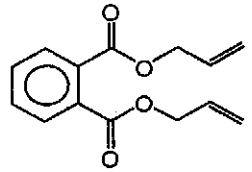
		Step I	Step II	Step III	Step IV
	A	substitution	condensation	substitution	condensation
	B	hydrolysis	elimination	condensation	addition
	C	addition	reduction	addition	elimination
	D	substitution	oxidation	oxidation	oxidation

27 What is the IUPAC name of the organic compound shown below?



	A	Butyl butanoate	**B**	Ethyl butanoate
	C	Propyl ethanoate	**D**	Propyl propanoate

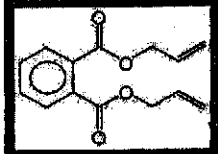
28 Which of the following statements are true about the polymer formed from dially phthalate?



dially phthalate

	1	It is a condensation polymer.
	2	It can form cross-links through the ester groups.
	3	It cannot be recycled.

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



29 Which statements are **incorrect** about addition polymers polyethene and polyvinylchloride?

	1	On complete combustion, both polymers produces carbon dioxide and water only
	2	Both polymers are not biodegradable
	3	Both polymers releases water as a by-product of polymerisation

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

[Turn over

30	Four students recorded some observations about polyesters and attempted to explain them. Which student is correct?		
		Observation	Reason
	A	All polyesters are made from two different monomers.	Ester linkages formed between the alcohol functional group of one of the monomers and the carboxylic acid functional group of the other monomer.
	B	Polyesters are biodegradable.	The ester linkages are easily broken just using water.
	C	Polyester bottles cannot be left in out in the open.	The high temperature from the sun provides sufficient energy to break the covalent bonds in the polyester.
	D	Polyester fabric are usually wrinkle-free.	Polyester chains do not readily form hydrogen bonds with each other.

[redacted]

Anderson Serangoon Junior College

Preliminary Examination - JC2 H1 Chemistry Paper 2

Section A

1 (a) (i) To prevent sodium **from coming into contact with air/oxygen/water**. [1]

(ii) $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$ [1]

(iii) Potassium atoms **lose their valence electrons** to form K^+ cations **more easily** [1], as the electron to be removed experiences a **greater shielding effect** as the electron is **further away** from the nucleus. [1]

(iv) Down the group, there is a greater tendency to be oxidised, **reducing power increases**. [1]

(b) (i) 11 electrons, 11 protons and 13 neutrons. [1]

(ii) Across the period, **nuclear charge increases**, **shielding effect is about the same** as the valence electrons are in the **same principal quantum shell**. [1]

Electrostatic force of attraction between nucleus and valence electrons increases and hence the **atomic radius decreases**. Hence **Na would have the larger radius**. [1]

(iii) $\frac{C}{C_o} = (\frac{1}{2})^n$

$0.10 = (\frac{1}{2})^n$

$-1 = n\log(\frac{1}{2})$

$n = 3.322$

Since one half life is 15 hrs

3.322 half life means:

time elapsed = 15 x 3.322

= **49.8 hours** [1]

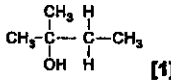
(c) (i) **A**: Na_2O **B**: Al_2O_3 **C**: SiO_2 [1]

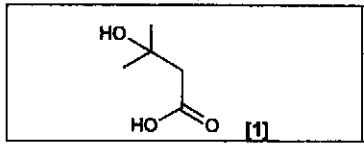
(ii) Acid-base [1]

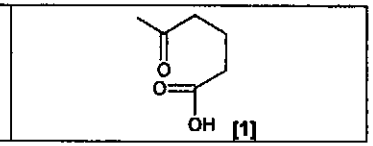
2 (a) (i) The **O–H bond** in ethanol is **more polar than** the **N–H bond** in ethylamine. Hence more energy is needed to overcome the **stronger intermolecular hydrogen bonding** between molecules of ethylamine. [1]

(ii) Substitution [1]

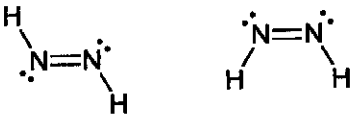
NaOH (aq), heat [1]

(b) (i)  [1]

(ii)  [1]

 [1]

(c)



[1] either one

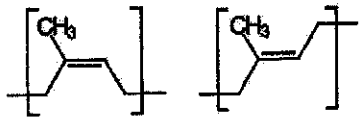
The 3 electron pairs around each nitrogen atom are arranged as far away as possible in order to minimise inter-electronic repulsion. Since lone – pair repulsion > lone pair – bond pair repulsion > bond pair – bond – pair repulsion, [1]

The shape is bent about each N atom with a bond angle of 119° (accept from 111° to 119°). [1]

(d) (I) Addition polymerisation [1]

(II) Thermoset. It has high tensile strength / rigid /inflexible and chars when heated. [1]
Cross links between polymer chains can be formed via opening of the double bond in the side chains forming covalent bonds. [1]

(III)



[1] ; [1]

Note: Not marking for labelling of cis-trans

(e) (i) A polymer with a higher value of Young's Modulus, correlates to a more rigid polymer. [1]

(II)

[1]

(III) As LDPE contains highly branched chain polymers it will lead to lesser surface area of contact between molecules which results in weaker intermolecular forces, allowing for the molecules to slide over each other (stretched). **[1] mark for understanding**

(iv) D: polycarbonate [1] E: HDPE [1] F: Cis-1,4-polyisoprene [1]

3 (a) (I)

run	relative rate
1	0.0625
2	0.1887
3	0.1000
4	0.2500

[1] for correct rate conversion from time for all 4 experiments

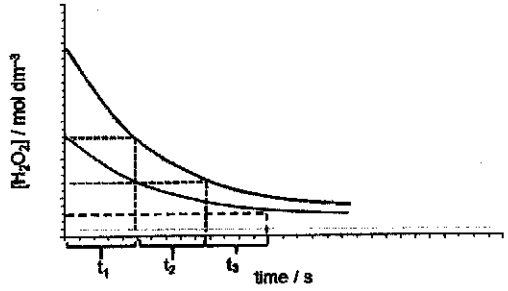
Comparing Expt 1 and 4, keeping conc of hydrogen peroxide and hydrogen ions constant, when the concentration of iodide ions is increased by 4x, the initial rate is also increased by 4x. Thus the order with respect to iodide ions is 1. **[1]**

Comparing Expt 1 and 2, keeping conc of iodide ions and hydrogen ions constant, when the concentration of hydrogen peroxide is tripled, the initial rate is also tripled. Thus the order with respect to hydrogen peroxide is 1. **[1]**

Comparing Expt 2 and 3, keeping conc of iodide ions constant, when the conc of hydrogen peroxide is halfed and the hydrogen ions is increased by 10x, the initial rate is doubled. Thus the order with respect to hydrogen ions is zero. **[1]**

(II) Rate = $k[H_2O_2][I^-]$ [1] $mol^{-1}\ dm^3\ s^{-1}$ [1]

(III)



[1] for (III); [1] for (IV)

(IV) Although $[H_2O_2]$ is halved, the half-life remains the same as it is independent of $[H_2O_2]$. [1]

(b) (I) Mass of $H_2O_2 = 0.03 \times 60 = 1.8$ g

$n(H_2O_2) = 1.8 / 34 = 0.05294$ mol

$[H_2O_2] = 0.05294 / 0.06 = 0.882$ mol dm^{-3} [1]

(II) $Q_{water} = mc\Delta T = (60)(4.18)(17.2) = 4313.76$ J [1]

$Q_{cup} = C\Delta T = (5)(17.2) = 86$ J [1]

$Q_{total} = Q_{water} + Q_{cup} = 4313.76 + 86 = 4399.76 = 4400$ J (3sf) (shown)

(III) $\Delta H = -Q / n = -4400 / 0.05294 = -83.1$ kJ mol^{-1} **[1] for final answer (ecf)**

(IV) $\Delta H_{formation} = -285.8 - (-83.1) = -202.7$ kJ mol^{-1}

[1] for application of Hess Law using energy cycle **[1] for answer**

(v) The value of the rate constant will increase. [1]

Increase in temperature will lead to an increase in the rate of reaction. Since the volumes and concentrations of the reactants remains uncharged, the rate constant must have increased. **[1] mark for understanding**

4 (a) (I) If a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium moves to counteract the change. [1]

(II) Since the forward reaction is exothermic, then applying Le Chatelier's Principle, the production of NH_3 is favoured by a low temperature. However, if the temperature is too low, the rate of reaction will be too slow making the process uneconomical. Hence a moderate temperature of 450 °C is used coupled with finely divided iron as a catalyst to obtain a reasonable yield of NH_3 in a short time. [1]

Since there are **lesser moles of gaseous products than reactants**, then applying Le Chatelier's Principle, the production of **NH_3 is favoured by a very high pressure**. However, **very high pressure demands higher costs** of plant construction and maintenance. Hence **moderately high pressure of 250 atm** is used. **[1]**

(iii)

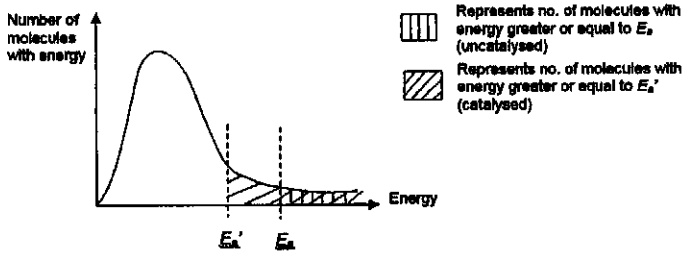
	N_2	+	$3H_2$	⇌	$2NH_3$
Initial amt / mol	1		1		–
Δ amt / mol	−0.106		−3 x 0.106		+2 x 0.106
Eqm amt / mol	0.894		0.682		0.212

[1] for the correct eqm amounts of H_2 and NH_3

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(\frac{0.212}{1})^2}{(\frac{0.894}{1})(\frac{0.682}{1})^3} = 0.158 \text{ mol}^{-2} \text{ dm}^6$$ **[1] for correct *K*c and units**

(iv) When temperature increases, **position of equilibrium shifts left to remove heat**, favouring endothermic reaction, decreasing [NH_3]. **K_c decreases**. **[1]**

(b)



[1] for correct diagram

- A catalyst providing a different reaction path which has **lower activation energy**.
- **Number of reactant molecules with energy greater or equal to the lowered activation energy (E_a') will increase.**

[1] for the above 2 points

- This results in an **increase** in the **frequency of effective collisions**.
- Hence, the **rate of reaction increases**.

[1] for the above 2 points

(c) **(i)** $[OH^-] = 0.016 \times 2$ **[1]**
$pOH = -\lg 0.032 = 1.495$
$pH = 14 - pOH = 14 - 1.495 = 12.5$ **[1]**

(ii) $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ **[1]**

Section B

5 **(a)** **(i)** Sodium chlorate(I) has a **giant ionic structure**. Presence of **ion-dipole interaction** allow it to be soluble in water. **[1]**

(ii) $2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O$ **[1]**

(iii) 0 in Cl_2, −1 in $NaCl$ and +1 in $NaClO$ **[1] for all three**

Disproportionation reaction has occurred / **Chorine undergo reduction and oxidation at the same time**. **[1] do not accept "redox" without the idea that its happening at the same time to Cl_2**

(b) **(i)** Amount of $Fe^{2+} = \frac{14.50}{1000} \times 0.00035 = 5.08 \times 10^{-6}$ mol

Amount of ClO_3^- in 25 $cm^3 = (5.08 \times 10^{-6}) \div 5 = 1.015 \times 10^{-6}$ mol **[1]**

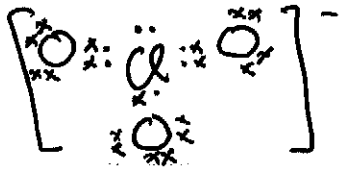
Amount of ClO_3^- in 250 $cm^3 = 1.015 \times 10^{-6} \times \frac{250}{25} =$ **1.02×10^{-5} mol** **[1]**

(ii) Molar mass of $ClO_3^- = 35.5 + 3(16) = 83.5$

$[ClO_3^-]$ in mol $dm^{-3} = \frac{1.02 \times 10^{-5}}{250/1000} = 4.08 \times 10^{-5}$ mol dm^{-3} **[1]**

$[ClO_3^-]$ in g $dm^{-3} = 4.08 \times 10^{-5} \times 83.5 =$ **0.00341 g dm^{-3}** **[1]**

(iii)

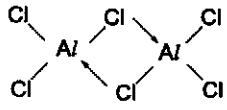


[1]

(c) **(i)** Sodium chloride has **a giant ionic structure**. Larger amount of energy is required to overcome the **stronger electrostatic forces of attraction between the oppositely charged ions.** **[1]**

Aluminum chloride has **simple molecular structure**. Lesser amount of energy is required to overcome the **weaker intermolecular forces of attraction** between the molecules. **[1]**

(ii)



[1]

$AlCl_3$ dimerises. Al is electron deficient and is able to accept a lone pair of electrons from Cl **[1]**

(iii) **White solid** and **white fumes** will be observed. **[1]**

$AlCl_3(s) + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3HCl(g)$ **[1] Ignore s.s.**

(iv) Difference 1:
Aluminium chloride when dissolve in water will give a resultant solution of pH : 3 or give an acidic solution. Sodium chloride give a neutral solution of 7 **[1]**

$[Al(H_2O)_6]^{3+} \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H^+$ **[1]**

Due to the **smaller cation size** and a **larger positive charge,** and hence a **higher charge density** of Al^{3+} (high polarising power), it is able to draw electrons to itself from the oxygen atoms of the neighbouring water molecules, which further polarises the O-H bonds, thereby producing H^+ in the solution. **[1]**

Difference 2:
When reacted with sodium hydroxide, aluminum chloride will form a white ppt which is soluble in excess. For sodium chloride, no ppt is observed.. **[1]**

$AlCl_3 + 3NaOH \rightarrow Al(OH)_3 + 2NaCl$
$AlCl_3 + 4NaOH \rightarrow Na[Al(OH)_4] + 3NaCl$ **[1] for equations**

6 (a) (i) Intial vol (Vol hydrocarbon + Vol reacted O_2 + Vol unreacted O_2)

Resultant vol (Volume of CO_2 – Vol unreacted O_2)

30 = initial vol – resultant vol

$30 = V_{hydrocarbon} + V_{reacted\ O2} + V_{unreacted\ O2} - V_{CO2} - V_{unreacted\ O2}$

30 = 10 + reacted O_2 – 40

Reacted O_2 = 60 cm^3 **[1]**

(ii) $C_xH_y + \left(x + \frac{y}{4}\right) O_2 \rightarrow xCO_2 + \frac{y}{2} H_2O$

10 60 40

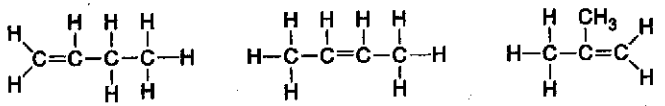
Using Avogadro's Law, comparing mole ratio and volume ratio of C_xH_y and CO_2

$\frac{x}{1} = \frac{40}{10}$ ➔ x = 4 **[1]**

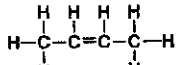
Compare mole ratio and volume ratio of C_xH_y and O_2

$4 + \frac{y}{4} = 6$ ➔ y = 8 **[1]**

(b) (i) Constitutional isomerism arises when the compounds have the **same molecular formula** but **different structural formula**. **[1]**

(ii) 

[1] for any two correct, [2] for all three correct

(iii) 

Only has *cis-trans* isomerism **[1]**

Reasons: **[1] for both reasons**

(i) C=C prevents free rotation about the double bond

(ii) Two different groups /atoms attached to each C atom of the C=C

(c) NaCl undergo hydration with water forming a neutral solution. pH of NaCl is 7. **[1]**

For $MgCl_2$, due to the smaller cation size and a larger positive charge as compared to Na^+, Mg^{2+} has a higher charge density as compared with Na^+. Hence slight hydrolysis occurs to form a slightly acidic solution of pH 6.5. [1]

$MgCl_2$ (s) + 6 H_2O (l) → $[Mg(H_2O)_6]^{2+}$ (aq) +2 Cl^- (aq)

$[Mg(H_2O)_6]^{2+}$ (aq) ⇌ $[Mg(H_2O)_5(OH)]^+$ (aq) + H^+ (aq) [1] for both equations

$SiCl_4$ undergoes **complete hydrolysis in water** to produce very acidic solutions of **pH 1.5** (accept a value from 1 to 2). **[1]**

$SiCl_4$ (l) + 4 H_2O (l) → $SiO_2.2H_2O$ (s) + 4 HCl (aq) [1]

(d) (i)
- Valence electrons are **further from the nucleus / more electron shells leading to higher shielding effect**.
- There are **weaker electrostatic forces of attraction between the nucleus and the valence electrons**.

[1] for the 2 points

Thus, ability of X to gain electrons (get reduced) decreases → **oxidising power decreases** **[1]**

(ii) X_2 is Cl_2, Y_2 is Br_2, Z_2 is I_2 **[1]**

(iii) Due to the **small size of fluorine atoms**, it leads to the **greater repulsion between fluorine electrons**. **[1]**

(e) (i) (Limited) Br_2 , ultraviolet light or heat **[1]**

(ii) There are 3 types of environment the H atoms to give **L**, **M** and **N**.

- only 1 possible H atom can be replaced to form **L**.
- 6 possible H atoms can be replaced to form **M**.
- 9 possible H atoms can be replaced to form **N**.

[1] for the reasons above

Hence, ratio of **L : M : N** = 1 : 6 : 9 **[1]**

END OF PAPER