HWA CHONG INSTITUTION
C2 Preliminary Examinations
Higher 1

NAME _____ **CT GROUP** _____

CHEMISTRY

8873/01

Paper 1 Multiple Choice

21 September 2020

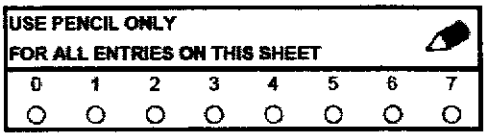
1 hour

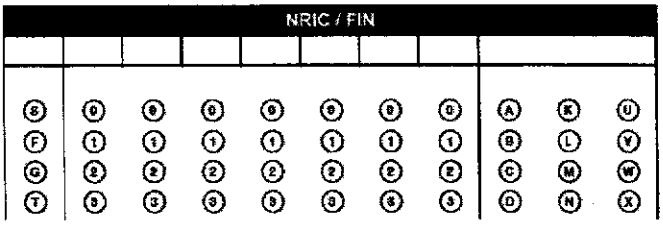
Additional Materials: Multiple Choice Answer Sheet
Data Booklet.

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Complete the information on the Answer Sheet as shown below.

1. Enter your **NAME** (as in NRIC). _____
2. Enter the **PAPER NUMBER**. _____
3. Enter your **CT GROUP**. _____
4. Enter your **NRIC NUMBER** or **FIN Number**
5. Now **SHADE** the corresponding circles in the grid for **EACH DIGIT** or **LETTER**





There are 30 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.

1 Elements M and N have the following successive ionisation energies in kJ mol^{-1}.

	1st	2nd	3rd	4th	5th	6th	7th
M	580	1800	2700	11600	14800	18400	23300
N	1300	3400	5300	7400	11000	13000	21000

What could be the chemical formula of the compound formed by these two elements?

A MN_2

B MN_3

C M_2N_3

D M_3N_2

2 Which particle would have a half-filled set of p orbitals on losing an electron?

A Si^- **B** P **C** P^- **D** S^+

3 Which statement about the properties associated with ionic and covalent bonds is correct?

A Some covalent compounds can serve as electrolyte in water.

B Ionic bonds and covalent bonds cannot both occur in the same compound.

C Ionic compounds and metals can conduct electricity in both the solid and liquid states.

D Any covalent compounds that have both hydrogen and oxygen in its molecule can form intermolecular hydrogen bond.

4 Some covalent molecules react to form ions. For example, NH_3 reacts with HCl to form NH_4^+ and Cl^-. In these reactions, the bond angles in the reactants differ from those in the ions they form.

Which of the following pairs does the first compound have a smaller bond angle about the central atom than the corresponding ion formed?

A CO_2, CO_3^{2-}

B $AlCl_3$, $AlCl_4^-$

C NH_3, NH_4^+

D BF_3, BF_4^-

5 Which set shows an increasing trend in radius?

A Na^+, Ne, F^-

B Al^{3+}, P^{3-}, Cl^-

C Ne, Mg^{2+}, Al^{3+}

D S^{2-}, Cl^-, Ar

6 **F**, **G** and **H** are consecutive elements in the third period of the Periodic Table. Among them, element **G** has the highest first ionisation energy and the lowest melting point.

What could be the identities of **F**, **G** and **H**?

	F	G	H
A	aluminium	silicon	phosphorus
B	aluminium	magnesium	silicon
C	silicon	phosphorus	sulfur
D	sodium	magnesium	aluminium

7 Consider the oxides of the Period 3 elements.

Which property decreases from Na_2O to SiO_2 and also from SiO_2 to P_4O_{10}?

A covalent character

B melting point

C pH when mixed with water

D solubility in aqueous alkali

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

Which statement is correct for the following hydrogen halides in the sequence shown?

HCl, HBr, HI

A The bond strength increases.

B The ease of oxidation increases.

C The thermal stability of the compounds increases.

D The bond polarity between hydrogen of halide atom increases.

9 Which statements about a 35.5 g of chlorine gas are correct?

1 The number of atoms is the same as the number of ions in 31.9 g of Fe_2O_3.

2 The number of atoms is the same as the number of electrons in 1 g of hydrogen gas.

3 The number of atoms is the same as the number of oxygen atoms in 11.35 dm^3 of oxygen gas at s.t.p.

A 1 and 2 only

B 2 and 3 only

C 1 and 3 only

D All of the above

10 One brand of antacid chewing gum contains 2.5% by mass of urea. The urea present in the chewing gum will react with aqueous acid in the mouth to give carbon dioxide and ammonium salt according to the equation below.

$$\underset{\text{urea}}{CO(NH_2)_2\,(aq)} + 2H^+\,(aq) + H_2O\,(l) \rightarrow CO_2\,(g) + 2NH_4^+\,(aq)$$

What is the mass of chewing gum that would be required to neutralize 20 cm^3 of a 0.10 mol dm^{-3} aqueous HCl solution?

A 0.06 g

B 0.12 g

C 1.50 g

D 2.40 g

11 Which of the following enthalpy changes are endothermic?

1 $Al(g) \rightarrow Al^{+}(g) + e^{-}$

2 $O^{-}(g) + e^{-} \rightarrow O^{2-}(g)$

3 $Mg^{2+}(g) + 2Cl^{-}(g) \rightarrow MgCl_2(aq)$

A 3 only

B 1 and 2 only

C 1 and 3 only

D All of the above

12 50 cm^3 of 0.500 mol dm^{-3} aqueous hydrogen peroxide were placed in a polystyrene cup and its temperature was determined to be 23.0 °C. 10 cm^3 of 0.500 mol dm^{-3} $Fe(NO_3)_3$ solution was added to catalyse the reaction.

$$H_2O_2(aq) \rightarrow H_2O(l) + \tfrac{1}{2}O_2(g)$$

The mixture was stirred with a thermometer and a maximum temperature of 32.2 °C was recorded.

What was the enthalpy change of the reaction? [Assume that the specific heat capacity of the solution is 4.18 J $K^{-1}cm^{-3}$.]

A −77 kJ mol^{-1}

B −92 kJ mol^{-1}

C −2830 kJ mol^{-1}

D −2360 kJ mol^{-1}

13 The standard enthalpy changes of combustion of but-1-ene, $C_4H_8(g)$ is x kJ mol^{-1}.

The standard enthalpy change of the reaction 2 $C_2H_4(g) \rightarrow C_4H_8(g)$ is y kJ mol^{-1}.

What is the standard enthalpy change of combustion of ethene, $C_2H_4(g)$ (in kJ mol^{-1})?

A $\frac{x-y}{2}$ **B** $x + \frac{y}{2}$ **C** $\frac{x}{2} + y$ **D** $\frac{x+y}{2}$

14 Given the following reaction in a vessel:

$$A(g) + B(g) \rightleftharpoons 2C(g) + D(g) \qquad \Delta H < 0$$

Which change in conditions increases both the rate of reaction and yield of the products?

A decrease the volume of the vessel

B increase temperature and increase pressure

C decrease the temperature and increase the pressure

D add a suitable catalyst and add a suitable solvent to dissolve C

15 The hydrolysis of sucrose in aqueous solution is catalysed by hydrogen ions.

Which procedure can be used to determine the order of the reaction with respect to hydrogen ions?

A Measure the rate of the reaction several times, but with a different concentration of hydrochloric acid each time.

B Add a suitable indicator and watch for the time when the colour changes

C Remove samples at various time intervals and titrate against a standard solution of sodium hydroxide.

D Measure the change in pH during the reaction.

16 The equilibrium between Fe^{3+} and I^- may be represented by

$$2Fe^{3+}(aq) + 2I^-(aq) \rightleftharpoons 2Fe^{2+}(aq) + I_2(aq)$$

In a particular mixture, the equilibrium concentration of Fe^{3+} is 0.5 mol dm^{-3}.

What will be the new equilibrium concentration of Fe^{3+} if 0.5 moles of pure iron(II) sulphate is dissolved in 1 dm^3 of the mixture?

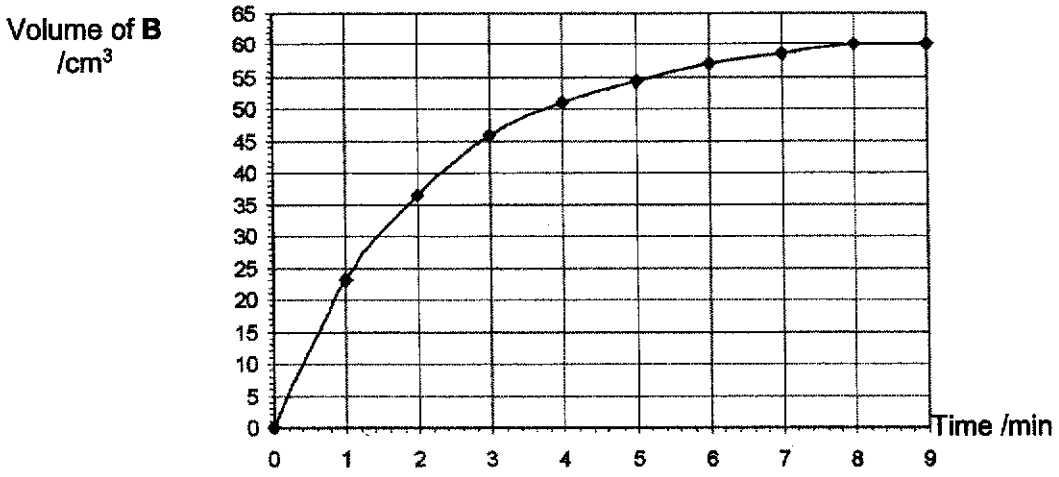
A 0.5 mol dm^{-3}

B 1.0 mol dm^{-3}

C between 0.5 mol dm^{-3} and 1.0 mol dm^{-3}

D more than 1.0 mol dm^{-3}

17 The reaction, 2A(aq) □ B(g), was monitored by measuring the volume of gas **B** formed at regular time intervals. The volume of **B** is plotted against time in the graph below.



Which statements are true about the reaction?

1 Doubling the concentration of **A** will increase the rate of reaction by 4 times.

2 The overall order of the reaction is one.

3 The rate constant is 0.462 min^{-1}.

A 1 only

B 1 and 3 only

C 2 and 3 only

D All of the above

18 N_2O_5 decomposes according to the equation.

$$N_2O_5 \longrightarrow 2NO_2 + \tfrac{1}{2}O_2$$

The decomposition is first order and the half–life of N_2O_5 is 150 s.

When a sample containing 0.10 mol of N_2O_5 was placed in a 1 dm^3 vessel, what is the concentration of NO_2 after 5 minutes?

A 0.150 mol dm^{-3}

B 0.100 mol dm^{-3}

C 0.050 mol dm^{-3}

D 0.025 mol dm^{-3}

19 The chemical equation for the redox reaction between iron (II) and silver (I) is given below:

$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$$

The equilibrium constants were measured to be 3.14 mol^{-1} dm^3 at 25°C and 1.2 mol^{-1} dm^3 at 35°C.

Which statement is **false**?

A The forward reaction is exothermic.

B The value of $\frac{[Fe^{2+}][Ag^+]}{[Fe^{3+}]}$ is 0.318 mol dm^{-3} at 25°C.

C The addition of aqueous sodium chloride has no effect on the position of the equilibrium.

D The addition of silver solid has no effect on the position of the equilibrium.

20 Which species behave as Brønsted-Lowry acids in the following reversible reaction?

$$H_2PO_4^-(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + HPO_4^{2-}(aq)$$

A HCN and CN^-

B HCN and $H_2PO_4^-$

C HCN and HPO_4^{2-}

D $H_2PO_4^-$ and HPO_4^{2-}

21 1.6 mol of pure nitrosyl chloride gas, NO*Cl*, was heated at 320 °C in a 2.0 dm^3 vessel. At equilibrium, 40% of the NO*Cl* gas has dissociated according to the equation below.

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

What is the numerical value of the equilibrium constant, K_c?

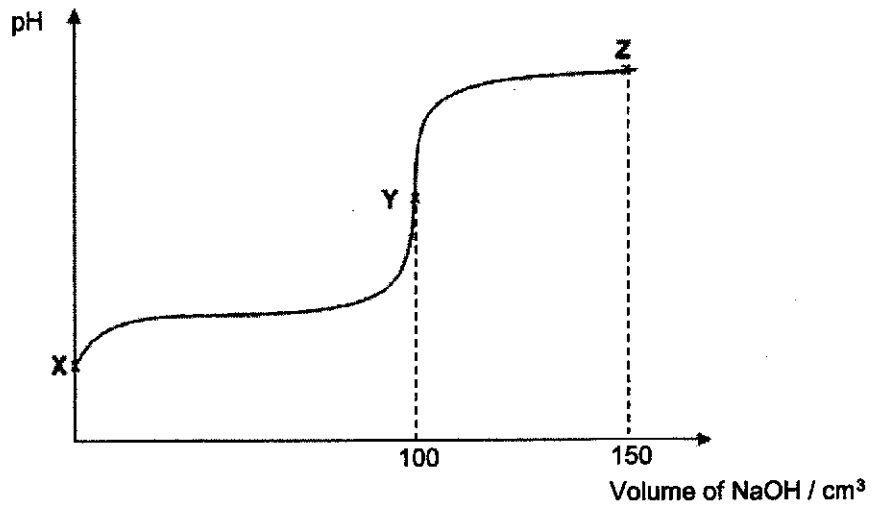
A 0.071

B 0.142

C 0.213

D 0.427

22 The pH curve below shows the pH change when 0.1 mol dm^{-3} of sodium hydroxide is added gradually to 100 cm^3 of 0.1 mol dm^{-3} of ethanoic acid.



The experiment is then repeated by adding 0.001 mol dm^{-3} sodium hydroxide to 100 cm^3 of 0.001 mol dm^{-3} ethanoic acid. A new pH curve is constructed for this experiment.

Which statement is correct about the new pH curve?

A The initial pH will be lower than that of point **X**.

B The pH at the equivalence point will be higher than that of point **Y**.

C The pH when 150 cm^3 of NaOH is added is lower than that of point **Z**.

D The equivalence point will be reached when less than 100 cm^3 of NaOH is added.

23 Which statements about a reversible reaction that is catalysed are correct?

1 The catalyst alters the pathway of the reaction.

2 The catalyst reduces the activation energy for both the forward and the backward reaction.

3 The catalyst alters the composition of the equilibrium mixture and the value of K_c.

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

24 Dichlorodifluoromethane, CCl_2F_2, has been used in aerosol propellants and as a refrigerant.

Which statement helps to explain why dichlorodifluoromethane is chemically inert?

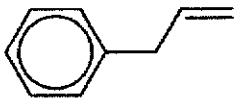
A The carbon-fluorine bond energy is large.

B The carbon-fluorine bond has a low polarity.

C Fluorine is highly electronegative.

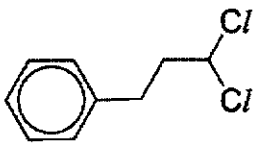
D Fluorine compounds are non-flammable.

25 3-phenylpropene and excess chlorine are mixed in the presence of uv light. Which compound is a possible product of the reaction?



3-phenylpropene

A



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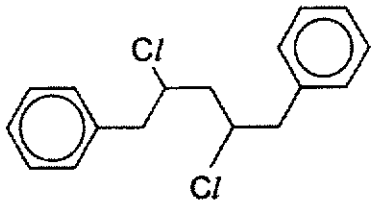

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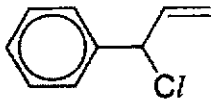

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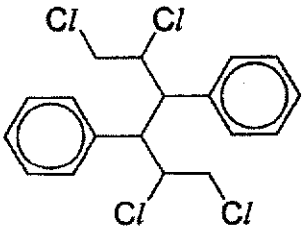


26 The conversion of propene into propanone can be accomplished in three steps.

Which combination of reagents could be used?

	Step 1	Step 2	Step 3
A	Br_2	alcoholic KOH; reflux	$H^+/KMnO_4$; reflux
B	Br_2	aqueous KOH; reflux	$H^+/KMnO_4$; reflux
C	HBr	alcoholic KOH; reflux	$H^+/KMnO_4$; reflux
D	HBr	aqueous KOH; reflux	$H^+/KMnO_4$; reflux

27 Malic acid, $HO_2CCH(OH)CH_2CO_2H$, is found in some fruits.

Which statement about malic acid is not true?

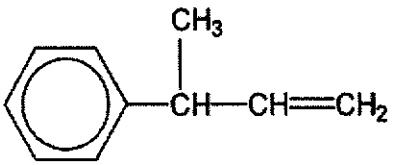
A It can undergo reduction to form alkene.

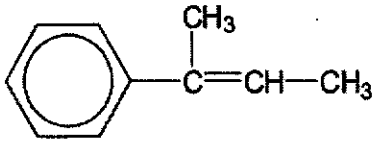
B Its molecule contains a secondary alcohol group.

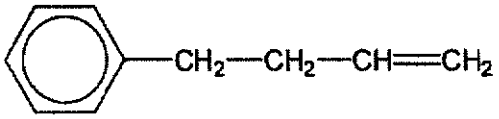
C It can form esters with both ethanoic acid and with ethanol.

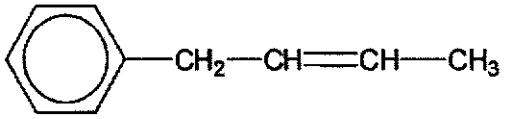
D 1 mole of malic acid will react completely with 3 moles of sodium metal.

28 Compound ***X*** has the molecular formula $C_{10}H_{14}O$ and is unreactive towards acidified $K_2Cr_2O_7$.
What is the structure of the compound formed by dehydration of ***X***?

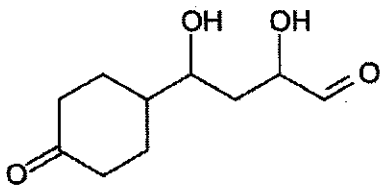
A 

B 

C 

D 

2 9 Which statements are true about the following compound?



1 Its molecular formula is $C_{10}H_{14}O_4$.

2 It reacts with sodium hydrogen carbonate to give carbon dioxide gas.

3 It reacts with hot acidified potassium dichromate to form a product with 5 O atoms.

4 It reacts with 2 mol of sodium metal to form 1 mol of hydrogen gas.

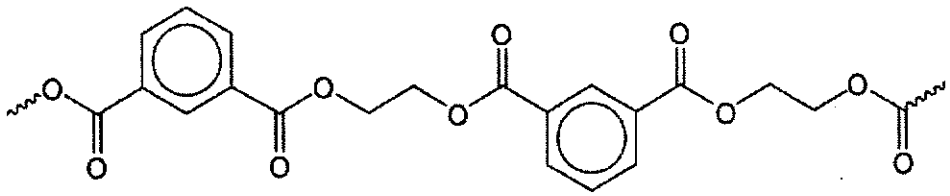
A 1 and 2 only

B 3 and 4 only

C 2 and 4 only

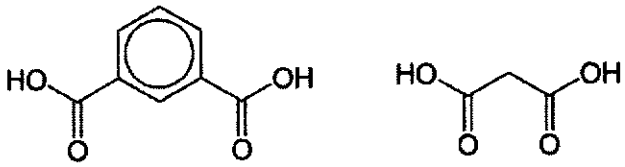
D 1 and 3 only

30 A polymer chain of PET is given below.



PET

Which are the monomers of PET?

A 

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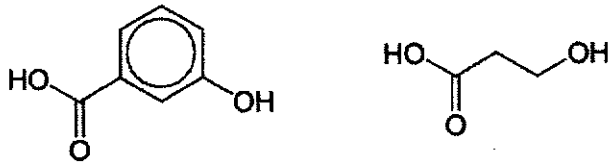
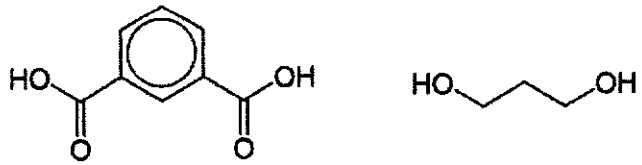
C 

D 

HWA CHONG INSTITUTION
C2 Preliminary Examinations
Higher 1

CANDIDATE NAME		CT GROUP	

CHEMISTRY

Paper 2

8873/02
31 August 2020
2 hours

READ THESE INSTRUCTIONS FIRST
Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use a 2B pencil for any diagrams or graphs.

Section A
Answer **all** the questions.

Section B
Answer **one** question.

The use of 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 EXAMINERS' USE ONLY

Paper 1	Paper 2				TOTAL
	Section A	Q1		/25	
		Q2		/15	
		Q3		/20	
	Section B	Either	Q4	/20	
		Or	Q5	/20	
/ 30		Subtotal		/ 80	

This question booklet consists of 22 printed pages and 1 blank page.

Section A

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

1 Ozone, O_3, is an allotrope of oxygen. It is a pale blue gas with a pungent smell.

(a) What do you understand by the term *allotrope*?

.....

.....

[1]

(b) **(i)** Draw a dot-and-cross diagram of ozone. The ozone molecule is non-cyclic and contains a dative bond.

[1]

(ii) Suggest a value for the bond angle in the ozone molecule.

Bond angle: .....

[1]

(iii) The strength of both oxygen-oxygen bonds in the ozone molecule is found to be equal. This contrasts with what is predicted by your answer in **(b)(i)**.

With reference to two relevant bond energy values in the *Data Booklet*, estimate a value for the oxygen-oxygen bond energy in the ozone molecule.

.....

[1]

Ozone is usually made by passing oxygen gas through a tube between two highly charged electrical plates.

$$3O_2(g) \rightarrow 2O_3(g)$$

The reaction does not go to completion, so a mixture of the two gases results.

The average M_r of the oxygen/ozone gaseous mixture may be calculated as follows:

average M_r = (mole fraction of O_2) × (M_r of O_2) + (mole fraction of O_3) × (M_r of O_3)

The ozone in the mixture can be determined by its reaction with aqueous KI.

$$O_3 + 2KI + H_2O \rightarrow I_2 + O_2 + 2KOH$$

The iodine formed can be determined by its reaction with sodium thiosulfate.

$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$$

(c) 800 cm^3 of an oxygen/ozone gaseous mixture at s.t.p. was passed into 1000 cm^3 of aqueous KI (an excess). 25.0 cm^3 of the resulting solution was pipetted. The iodine in this aliquot required 23.20 cm^3 of 0.0500 mol dm^{-3} $Na_2S_2O_3$ for complete reaction.

(i) Calculate the number of moles of ozone in the 800 cm^3 oxygen/ozone gaseous mixture.

[2]

(ii) Calculate the average M_r of the oxygen/ozone gaseous mixture.

[2]

Lead forms two chlorides, $PbCl_2$ and $PbCl_4$. When chlorine is passed into a saturated solution of $PbCl_2$ in NH_4Cl(aq), a yellow salt, Z, is formed. Z has the following composition by mass:

Cl, 46.7%; H, 1.76%; N, 6.14%; Pb 45.4%

Z is ionic with a formula mass of 456. One formula unit of Z contains one type of anion and one type of cation in the ratio 1:2.

(d) **(i)** Calculate the empirical formula of Z.

[2]

(ii) Suggest the formulae of each of the ions present in Z.

Anion: .....

Cation: .....

[1]

(iii) What is the oxidation state of Pb in Z?

.....[1]

(iv) Suggest the shape of the lead-containing ion.

.....[1]

(e) Define the term *bond energy*.

.....

.....

[1]

(f) Under certain conditions the hydrogen halides decompose into their elements.

$$2HX \rightleftharpoons H_2 + X_2 \qquad (X = Cl, Br \text{ or } I)$$

(i) How does the extent of this reaction vary down the group?

.....

[1]

(ii) Use bond energy values from the Data Booklet to calculate the ΔH for this reaction when X = C*l* and when X = I.

[2]

(iii) Use your results from **(ii)** to explain the trend stated in **(i)**.

.....

.....

.....

[2]

(g) The halogenoethanes C_2H_5Cl, C_2H_5Br, C_2H_5I differ in their physical properties and reactivity.

(i) Suggest and explain how the boiling points of these three compounds differ.

.....

.....

.....

.....

[2]

(ii) Suggest and explain how the C–X bond polarities in these three compounds differ.

.....

.....

.....

.....

[2]

(iii) Describe and explain how the reactivity of the three compounds differ when heated with aqueous sodium hydroxide.

.....

.....

.....

.....

[2]

[Total: 25]

2 (a) Nitrogen and phosphorus both form hydrides with the formulae NH_3 and PH_3 respectively. The boiling point of NH_3 is 240 K and that of PH_3 is 183 K. Suggest an explanation for the difference in these boiling points.

.....

.....

.....

[2]

(b) Nitrogen and hydrogen react together to form ammonia in the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

During the synthesis of ammonia, the following equilibrium concentrations were obtained.

molecule	equilibrium concentrations/ mol dm^{-3}
N_2	1.383
H_2	1.145
NH_3	0.236

Calculate the value and state the units of K_c for this reaction.

K_c = ...

Units: .....

[2]

(c) Explain in detail, with the aid of a Boltzmann distribution diagram, why a catalyst is used in the Haber process.

.....

.....

.....

.....

[3]

(d) (i) Write an equation and give the conditions for reaction between ammonia and bromoethane, CH_3CH_2Br.

Equation: .....

Conditions: .....

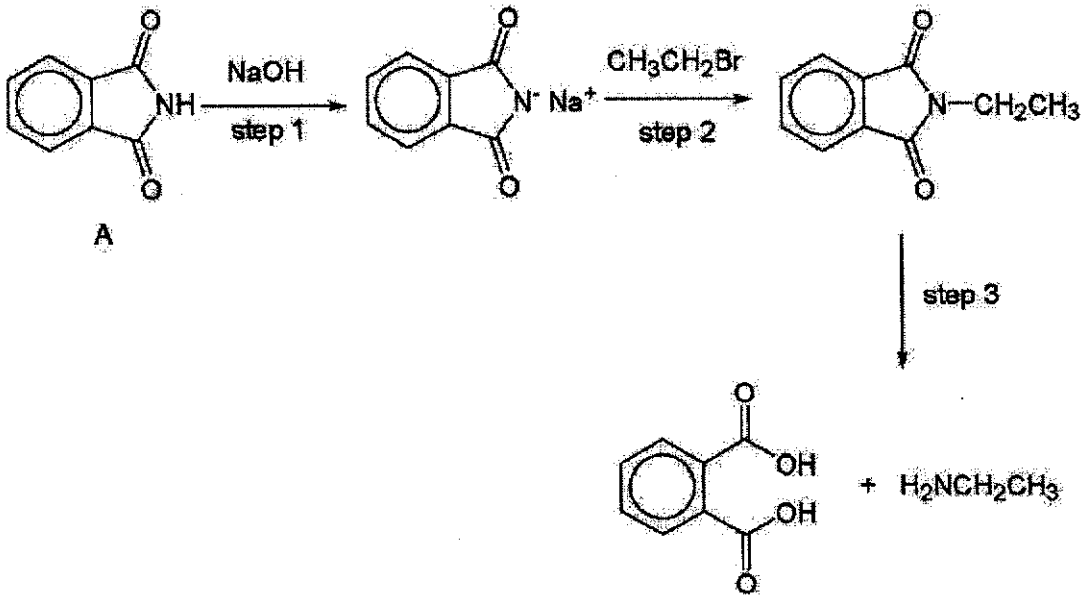
[2]

(ii) What type of reaction is this?

.....

[1]

(e) Compound A is a useful intermediate for making primary amines from bromoalkanes as shown by the following method.



A

(i) Name the functional group present in Compound A.

.....

[1]

(ii) What types of reaction are steps 1, 2 and 3?

Step 1: .....

Step 2: .....

Step 3: .....

[3]

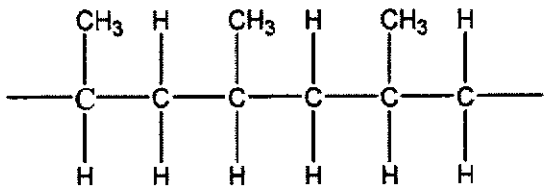
(iii) Suggest reagents and conditions for step 3.

.....

[1]

[Total: 15]

3 (a) A section of poly(propene) is given below.



(i) To which homologous series does poly(propene) belong?

.....
...

[1]

(ii) Accidents can cause damage to muscles. When a surgeon repairs a wound in a muscle, a mesh can be inserted below the muscle tissue so that on healing the wound is less likely to re-open and the repair is stronger. Poly(propene) is the recommended material for the mesh.

Suggest why poly(propene) is used rather than polyester or polyamide.

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...

[2]

Some of the hydrocarbon molecules obtained from crude oil are broken down by a process called *cracking*.

Cracking one mole of dodecane, $C_{12}H_{26}$, produces two moles of ethene and one mole of another hydrocarbon molecule.

(ii) Write the equation for this cracking reaction. Use molecular formulae to represent the hydrocarbon molecules.

.....
...

[1]

The ethene can be used in the production of poly(ethene).

(iii) State one reason why poly(ethene) should be reused or recycled rather than just thrown away.

.....
...

[1]

(b) There are two main types of poly(ethene), low density poly(ethene) (LDPE) and high density poly(ethene) (HDPE).

State and explain one difference in property between LDPE and HDPE, in relation to the structure of the polymer. Hence state one use of each type of poly(ethene).

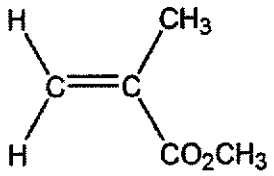
You may use suitable diagrams to illustrate the structures of LDPE and HDPE.

.....

.....

[6]

(c) Compound X can be used to make a polymer, via the same type of process as making poly(ethene) from ethene.



compound X

(i) Draw **one** repeat unit of this polymer of compound X.

[1]

(ii) With reference to the origin of cis-trans isomerism in alkenes, explain why compound X does not exhibit cis-trans isomerism. Draw a constitutional isomer of X which exhibits cis-trans isomerism.

.....
...

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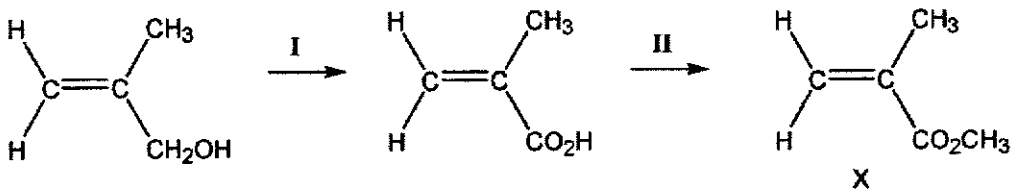
...

constitutional isomer of X which exhibits cis-trans isomerism:

[3]

(iii) Compound X can be synthesised via the reaction scheme below.



X

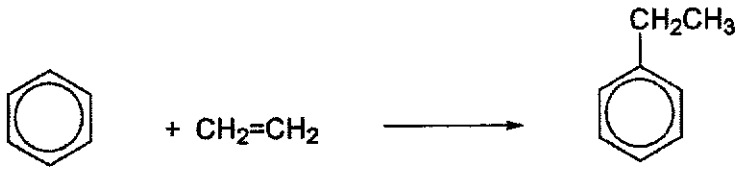
State the reagents and conditions needed for

step I .....

step II .....

[2]

(d) Benzene can react with ethene under certain conditions to form ethylbenzene.



ethylbenzene

(i) By using bond energy values from the *Data Booklet*, calculate the enthalpy change for the reaction to form ethylbenzene as shown above.

[1]

(ii) Use your answer from (i) to sketch a reaction pathway diagram for the reaction between benzene and ethene.

[2]
[Total: 20]

Section B

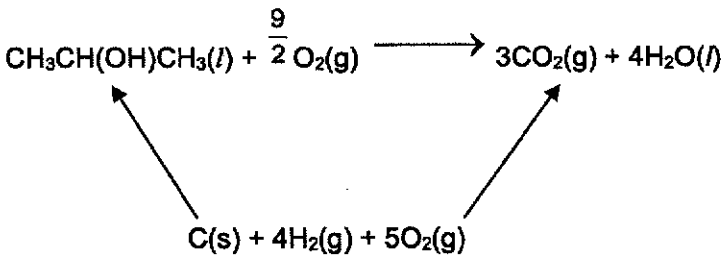
Answer **one** question from this section, in the spaces provided.

4 The enthalpy change of combustion of propan-2-ol is −2006 kJ mol^{-1}.

(a) Calculate the mass of propan-2-ol that needs to be burnt to bring 1.0 kg of water at 30 °C to 100 °C. Assume that the process is 80% efficient and the specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

[3]

(b) Consider the following energy cycle involving propan-2-ol.



(i) Define enthalpy change of combustion of propan-2-ol.

.....

.....

[1]

(ii) What does ΔH_1 represent?

.....

.....

[1]

(iii) Using the following data, calculate ΔH_1.

enthalpy change of combustion of carbon	= −393 kJ mol^{-1}
enthalpy change of combustion of hydrogen	= −285 kJ mol^{-1}
enthalpy change of combustion of propan-2-ol	= −2006 kJ mol^{-1}

[2]

(c) **(i)** Both magnesium and silicon react with chlorine to give their chlorides, which differ in their reaction with water. Write equations for the reactions of the chlorides with water.

.....

.....

[2]

(ii) Describe these differences, and explain them in terms of the structures and bonding of the chlorides.

.....

.....

.....

.....

[2]

(d) In the presence of platinum catalyst, ammonia is oxidised by air to nitric acid. The following equation is a summary of the overall process.

$$NH_3(g) + 2O_2(g) \rightarrow HNO_3(l) + H_2O(l)$$

The rate of reaction was measured at different times and the results are shown in the table below.

$[NH_3]$/mol dm^{-3}	rate/ mol $dm^{-3}s^{-1}$
2.20	22.7×10^{-4}
2.00	21.1×10^{-4}
1.80	18.9×10^{-4}
1.50	15.7×10^{-4}
1.25	13.7×10^{-4}
0.80	8.3×10^{-4}

(i) Plot a graph of rate against $[NH_3]$. [2]

(ii) Use your graph to find the order of the reaction with respect to $[NH_3]$.

[2]

(iii) The order of reaction with respect to oxygen is zero. Write an expression for the rate equation.

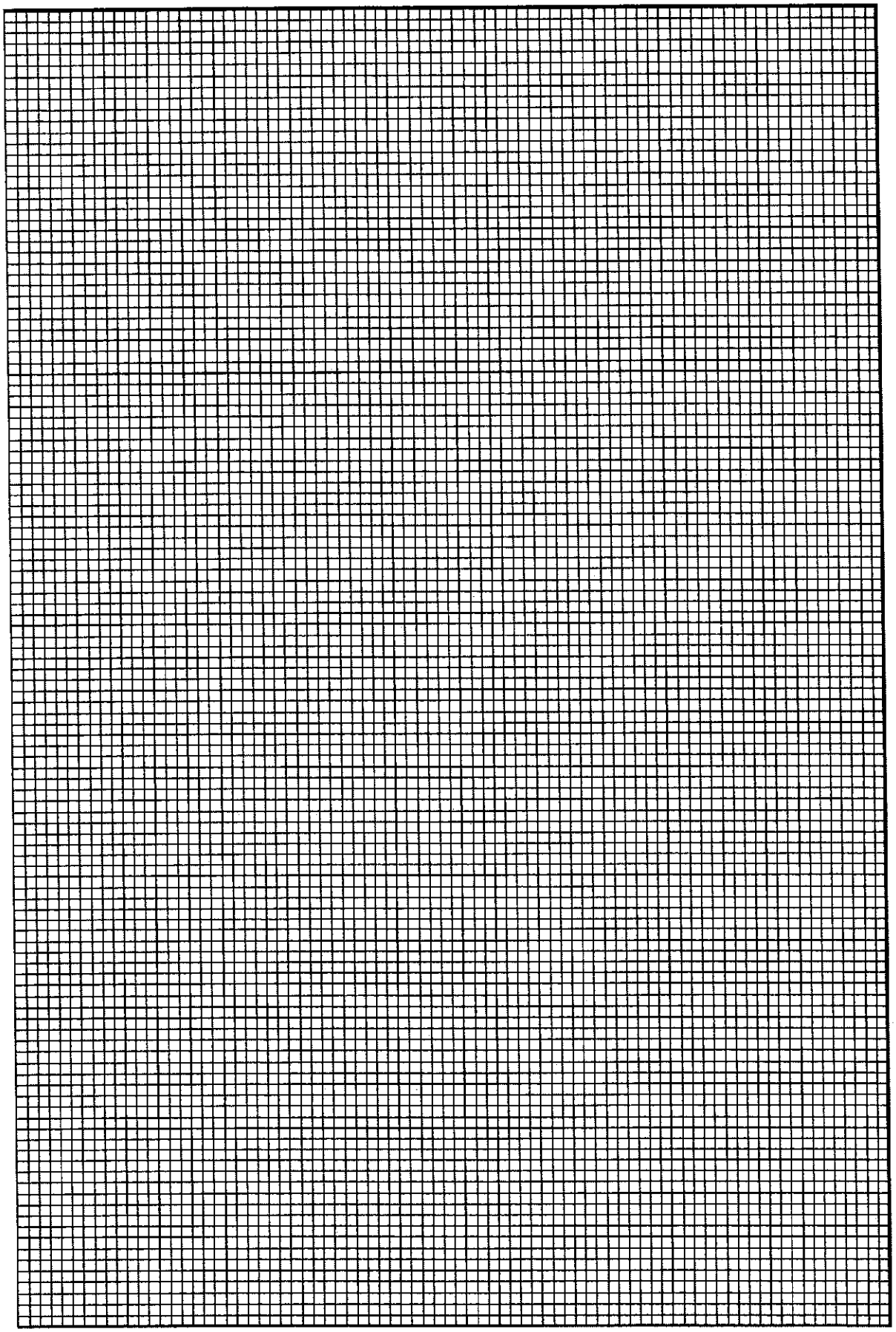
.....[1]

(iv) Calculate the rate constant giving its units.

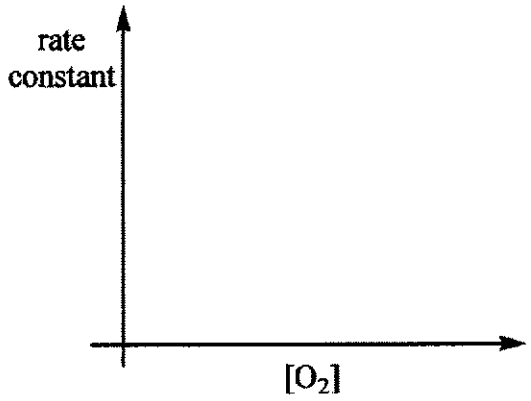
Value of *k* .....

Units of *k* .....

[2]

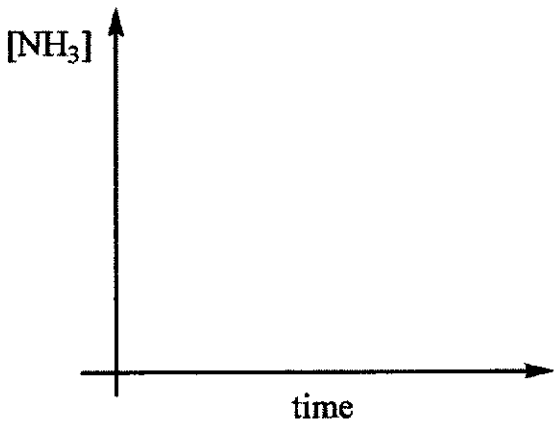


(v) Sketch a graph to show how the rate constant varies with the concentration of oxygen gas at constant temperature.



[1]

(vi) Sketch the shape of the graph of $[NH_3]$ against time.



[1]
[Total: 20]

5 **(a)** Highlight the key differences between thermoplastic and thermoset in terms of their structures and properties.

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.....

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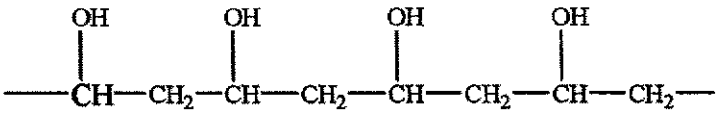
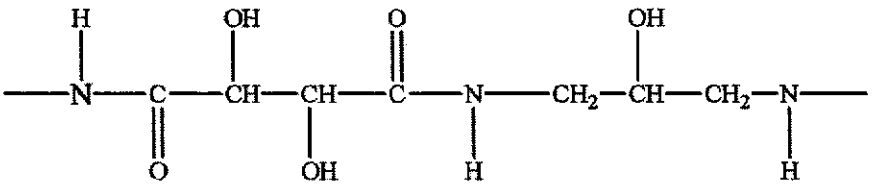
.....

[3]

(b) Hydrophilic polymers find important uses in the manufacture of contact lenses and wound dressings. Their chemical structures allow them to bond with water molecules, which keeps them soft and flexible. Sections of two hydrophilic polymers are shown below.



H



J

What type of polymerisation has produced

polymer H? .....

polymer J? .....

[2]

(c) What type of attractions might occur between these polymers and molecules of water?

.....

[1]

(d) Chains of polymer H can be cross-linked by reaction with a small bifunctional molecule.

(i) Which one of the following molecules would be most suitable for such cross-linking? (Place a tick in one box only)

$HOCH_2CH_2OH$ ☐

$H_2NCH_2CH_2NH_2$ ☐

$HOCH_2CH_2CO_2H$ ☐

$HO_2CCH_2CH_2CO_2H$ ☐

$H_2NCH_2CH_2CO_2H$ ☐

[1]

(ii) What type of bond would be formed during the cross-linking?

.....

[1]

(e) Draw the structures of the two products formed when polymer J is heated with hot aqueous sodium hydroxide.

[2]

(f) "Acidity regulators" are food additives that have a buffering action on the pH of foodstuffs. Mixtures of citric acid, $C_5H_7O_4CO_2H$, and its sodium salt are often used for this purpose. (K_a of citric acid = 7.4×10^{-4} mol dm^{-3})

$$C_5H_7O_4CO_2H \rightleftharpoons C_5H_7O_4CO_2^- + H^+$$

(i) Explain the term *weak acid*.

.....

.....

[1]

(ii) The concentration of citric acid in lemon juice is 0.22 mol dm^{-3}. Assuming that no other acid is present, calculate the pH of lemon juice.

[3]

(iii) Write equations to show how the citric acid/sodium citrate buffer system regulates the acidity on the addition of small amounts acids or base.

.....

.....

[2]

(iv) Calculate the pH of a solution containing 0.10 mol dm^{-3} citric acid and 0.30 mol dm^{-3} sodium citrate.

[2]

(v) Define the term K_w and explain why, at 25 °C, water has a pH of 7.

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.....

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[2]
[Total: 20]

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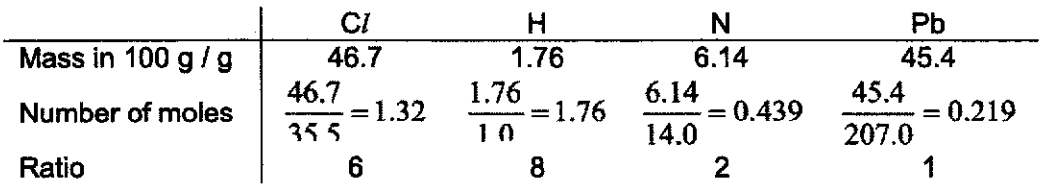
Answer

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

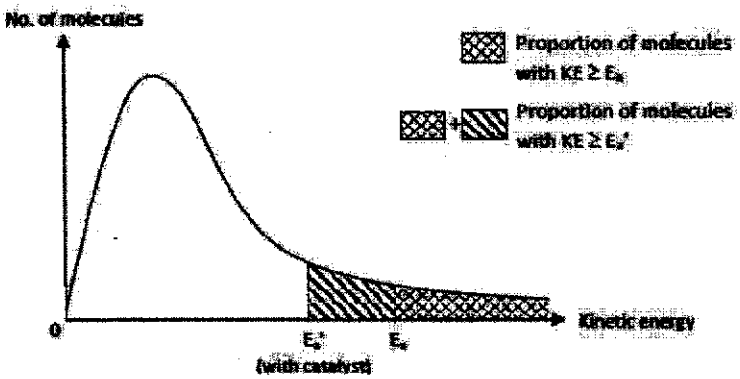
2020 H1 Chemistry Preliminary Examination Paper 2

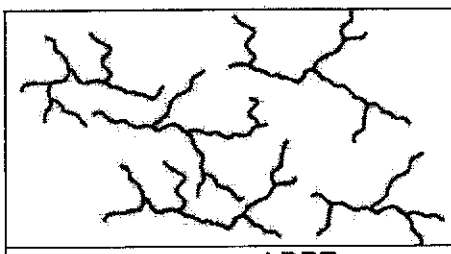
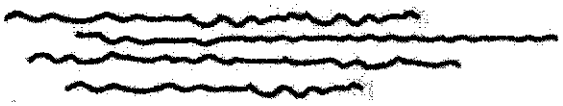
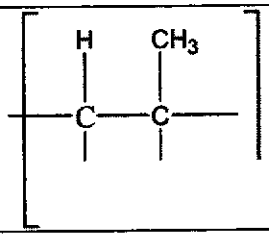
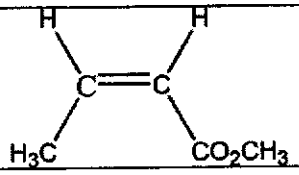
Suggested Solutions

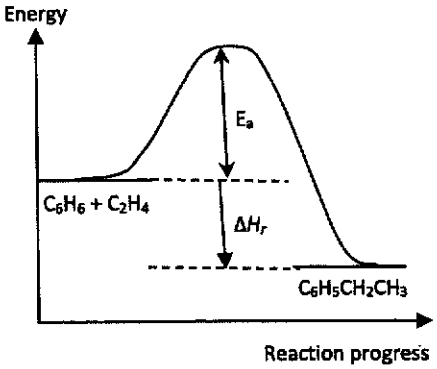
Section A

1(a)	An allotrope is a different form of the same element.
(b)(i)	
(b)(ii)	accept 111° to 119° (actual 116-117°)
(b)(iii)	O=O bond energy: 496 kJ mol^{-1} O−O bond energy: 150 kJ mol^{-1} The actual oxygen-oxygen bond energy is expected to be in-between that of a single and double bond, therefore estimate is (496+150) ÷ 2 = 323 kJ mol^{-1}
(c)(i)	number of moles of thiosulfate = 23.20 ÷ 1000 × 0.0500 = 0.00116 mol number of moles of iodine in aliquot = 0.00116 ÷ 2 = 0.00058 mol number of moles of ozone in the gaseous mixture = total number of moles of iodine produced = 1000 ÷ 25 × 0.00058 = 0.0232 mol
(c)(ii)	total number of moles of gas = 800 ÷ 22700 = 0.0352 mol mole fraction of ozone = 0.0232 ÷ 0.0352 = 0.659 average M_r = (1−0.659) × 32.0 + 0.659 × 48.0 = 42.5 (1dp or 3sf)
(d)(i)	 Empirical formula is $Cl_6H_8N_2Pb$.
(d)(ii)	Anion: $[PbCl_6]^{2-}$ Cation: NH_4^+
(d)(iii)	+4
(d)(iv)	octahedral
(e)	Bond energy of a bond X-Y refers to the energy required to break 1 mole of covalent bond X-Y in the gaseous state.

(f)(i)	Extent of reaction increases down the group.
(f)(ii)	$2HX\ (g) \rightleftharpoons H_2\ (g) + X_2\ (g)$ For X = Cl: $\Delta H = 2 \times 431 - 436 - 244 = +182\ kJ\ mol^{-1}$ For X = I: $\Delta H = 2 \times 299 - 436 - 151 = +11\ kJ\ mol^{-1}$
(f)(iii)	• The results from (ii) shows that down the group, the reaction becomes less endothermic, that is, less energy is required to carry out the reaction. • This is due to the weaker bond strength and longer bond length of the H-X bond down the group. Therefore reaction occurs to a greater extent down the group.
(g)(i)	Boiling points will increase in the order: $C_2H_5Cl < C_2H_5Br < C_2H_5I$ Due to larger number of electrons, hence larger size of electron cloud and stronger dispersion forces.
(g)(ii)	C–X bond polarity will decrease in the order: $C_2H_5Cl > C_2H_5Br > C_2H_5I$ This is due to decreasing electronegativity from Cl to I.
(g)(iii)	Reactivity towards nucleophiles will increase in the order: $C_2H_5Cl < C_2H_5Br < C_2H_5I$ Due to C–X bond strength decreasing (or weaker C–X bond) from C–Cl to C–I.

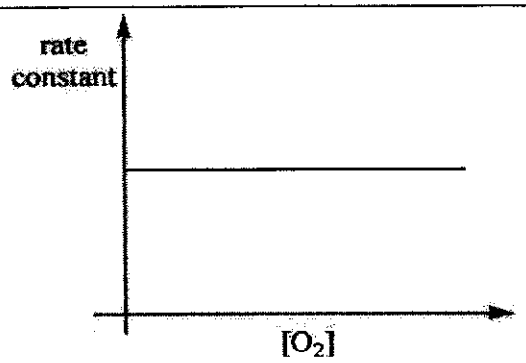
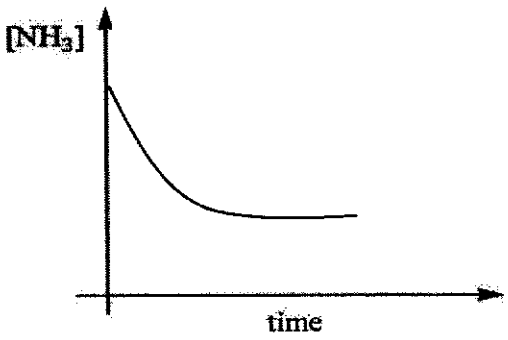
2(a)	• Both NH_3 and PH_3 are simple covalent molecules. • NH_3 molecules have hydrogen bonds between molecules while PH_3 molecules have weaker dispersion forces between them. • Hence, more energy is required to overcome the hydrogen bonding, resulting in a higher boiling point for NH_3.
2(b)	$K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3} = 0.0268 \text{ mol}^{-2} \text{ dm}^6$
2(c)	 A Fe catalyst provides an alternative reaction pathway for the Haber process which requires a lower activation energy (E_a') than the uncatalysed reaction (E_a). As represented by the shaded areas in the Boltzmann diagram, there is an increase in the fraction of reactant particles (N_2 and H_2 gases) that have kinetic energy greater than or equal to activation energy E_a'. This increases the frequency of effective collisions (rate constant increases) and reaction rate increases.
2(d)(i)	$CH_3CH_2Br + NH_3 \rightarrow CH_3CH_2NH_2 + HBr$ ethanolic concentrated NH_3, heat in sealed tube
2(d)(ii)	Substitution
2(e)(i)	Amide
2(e)(ii)	Step 1: acid-base reaction Step 2: substitution Step 3: hydrolysis
2(e)(iii)	Dilute H_2SO_4, heat

3(a)(i)	Alkane
(ii)	Poly(propene) is fully saturated, has no reactive group and is chemically inert, not biodegradable, not affected by enzymes. Polyester has ester linkage while polyamide has amid linkage, these linkages may be hydrolysed by acids, enzymes.
(iii)	$C_{12}H_{26}$ d $2C_2H_4 + C_8H_{18}$
(iv)	To reduce carbon footprint. To minimise plastic waste.
(b)	 LDPE  HDPE 2m for correct diagrams. LDPE: • Polymer chains are highly branched. They cannot pack together closely and regularly. They are more irregularly tangled together. • soft, very flexible, stretchy, used as plastic bags HDPE: • Polymer chains have minimal or no branching. They can arrange parallel to one another. They can pack closely together, giving a more regular structure with less empty space between adjacent chains. So there are more points of contact between adjacent chains for intermolecular dispersion forces to form. • harder, stiffer, much more rigid, used as plastic bottles, detergent bottles
(c)(i)	
(c)(ii)	For cis-trans isomerism, each C on the C=C should have a H atom and a R group. One carbon atom on compound X has a 2 H while the other C has 2 R groups, Hence, the reuqirements for cis-trans isomerism.
(c)(iii)	

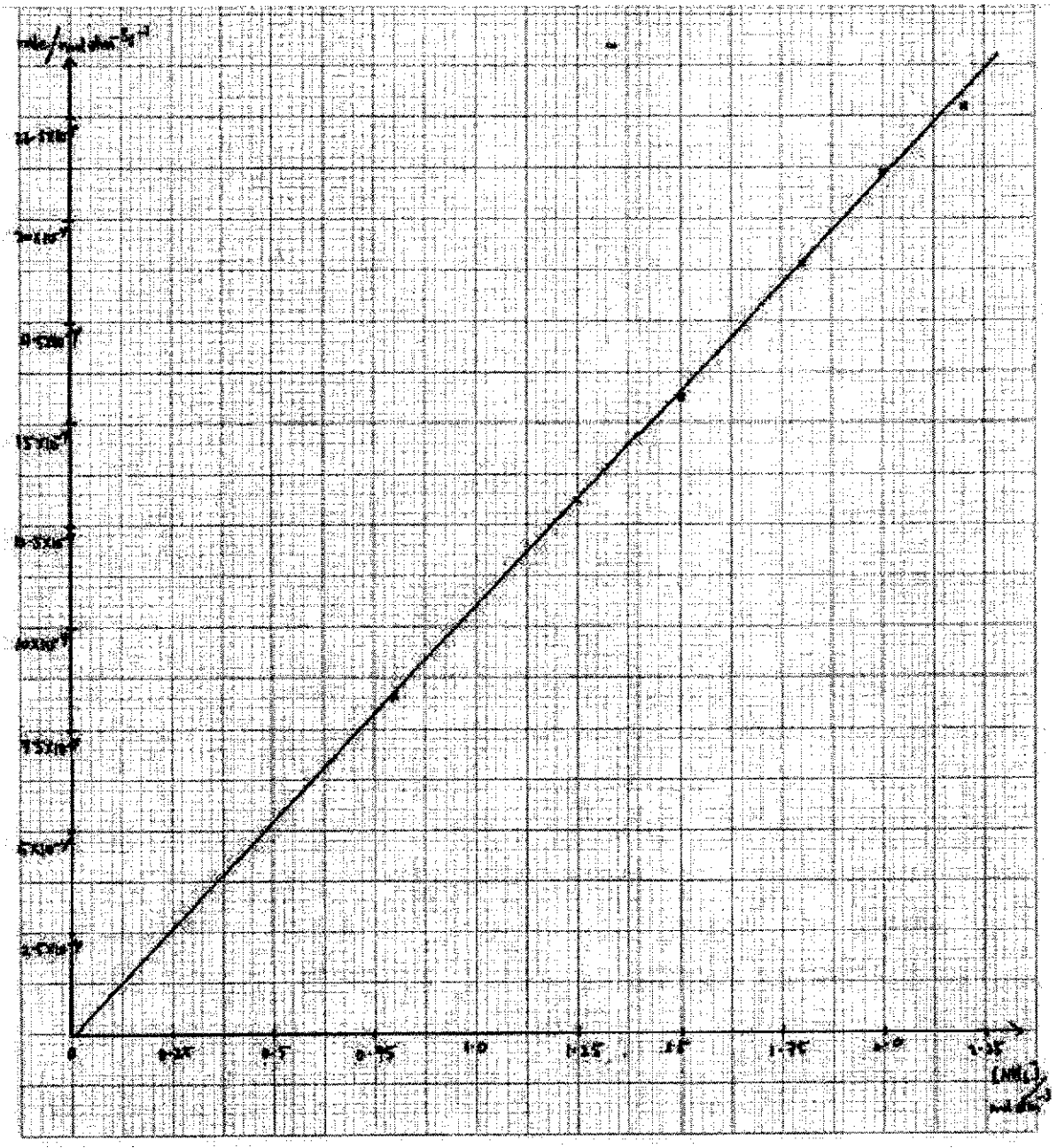
3(d)(i)	ΔH_r = BE(C=C) – 2BE(C-C) – BE(C-H) = 610 – 2(350) = –90 kJ mol^{-1}
3(d)(ii)	

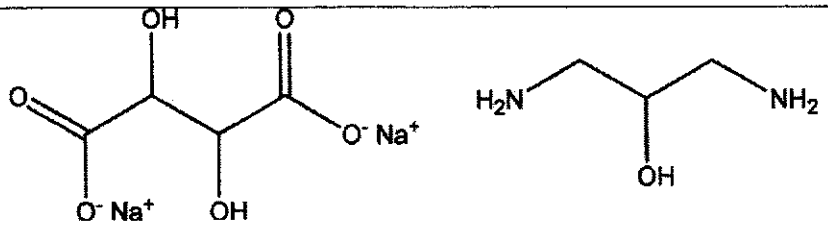
Section B

4(a)	Mr of propan-2-ol = 60; let mass of propan-2-ol needed = m g heat from burning of propan-2-ol = $0.80 \times \frac{m}{60} \times 2006 \times 10^3$ J heat gained by water = 1000 x 4.2 x 70 J heat from burning of propan-2-ol = heat gained by water $0.80 \times \frac{m}{60} \times 2006 \times 10^3 = 1000 \times 4.2 \times 70$ m = 11.0 g
(b)(i)	Heat evolved when 1 mole of propan-2-ol is completely burnt in excess oxygen
(ii)	enthalpy change of formation of 1 mol propan-2-ol from its elements in their standard states
(iii)	$\Delta H_1 = \Delta H_c$(products) – ΔH_c(reactants) = 3(□393) + 4(□285) □ (□2006) = □313 kJ mol□1
(c)(i)	$MgCl_{2(s)} + 6\ H_2O_{(l)}$ □ $[Mg(H_2O)_6]^{2+}_{(aq)} + 2\ Cl^-_{(aq)}$ $[Mg(H_2O)_6]^{2+}_{(aq)} + H_2O_{(l)}$ □ $[Mg(H_2O)_5OH]^+_{(aq)} + H_3O^+_{(aq)}$ $SiCl_{4(l)} + 4\ H_2O_{(l)}$ □ $SiO_2.2H_2O_{(s)} + 4\ HCl_{(aq)}$
(c)(ii)	$MgCl_{2(s)}$, a giant ionic salt, dissolves in water to form hydrated magnesium ions with a slightly acidic pH. The higher charge density of Mg^{2+} undergoes slight hydrolysis to form a very weakly acidic solution of around pH 6.5. $SiCl_{4(l)}$, a simple covalent molecule, undergo complete hydrolysis; reacts with water forming a very acidic solution.
(d)(i)	label axis correctly plot all points correctly on graph.
(d)(ii)	rate vs $[NH_3]$ is a straight line passing through origin, thus rate is directly proportional to $[NH_3]$ hence, reaction is first order wrt to NH_3.
(iii)	rate = $k[NH_3]$
(iv)	Using any point on the graph, $k = \frac{18.9 \times 10^{-4}}{1.8}$ $k = 1.05 \times 10^{-3}\ s^{-1}$

(v)	
(vi)	

4(d)(i)



5(a)	Thermoplastics are polymers that can be melted and recast almost indefinitely. There are no cross-links between polymer chains. They are molten when heated and harden upon cooling. Thermoplastics are usually more flexible. In thermosets, each polymer chain is linked to many other polymer chains by covalent bonds. The high degree of cross-linking greatly restricts movement of the polymer chains i.e. the polymer chains cannot move or slide past each other. The high degree of cross-linking also prevents the risk of the product remelting when heat is applied since a lot of energy is needed to break the many cross-linking covalent bonds. Thus the material is very rigid and hard.
5(b)	H: addition J: condensation
5(c)	Hydrogen bonding
5(d)(i)	$HO_2CCH_2CH_2CO_2H$
5(d)(ii)	Ester bond
5(e)	
5(f)(i)	A weak acid HA dissociates **partially** in water to give H_3O^+.
5f)(ii)	$K_a = [H^+][A^-]/[HA]$ Assume x is negligible $\frac{x^2}{0.22} = 7.4 \times 10^{-4}$ $[H^+] = x = 0.01276$ mol dm^{-3} pH = -lg [H⁺] = 1.89 (3 s.f.)
5(f)(iii)	$C_5H_7O_4CO_2H + OH^- \square C_5H_7O_4CO_2^- + H_2O$ $C_5H_7O_4CO_2^- + H^+ \square C_5H_7O_4CO_2H$
5(f)(iv)	$$pH = pKa + lg\frac{[A^-]}{[HA]}$$ $$pH = -lg\ lg\ 7.4 \times 10^{-8} + lg\frac{[0.3]}{[0.1]} = 7.61$$
5(f)(v)	At 25 °C, $K_w = [H^+][OH^-] = 1{\cdot}10^{-14}$ $[H^+] = [OH^-] = \sqrt{1{\cdot}10^{-14}} = 1{\cdot}10^{-7}$ pH = -lg [H⁺] = 7