RAFFLES INSTITUTION
2018 YEAR 6 PRELIMINARY EXAMINATION

Higher 1

CHEMISTRY 8873/01

Paper 1 Multiple Choice **24 September 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not open this question booklet until you are told to do so.

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

There are **thirty** questions in this section. 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.

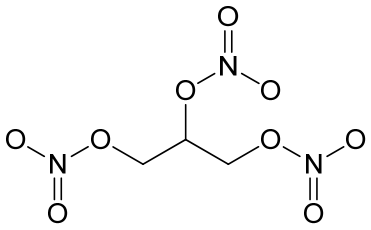
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in the question booklet.

This document consists of **15** printed pages.

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

1 Nitroglycerin is an explosive that decomposes to form carbon dioxide, water, nitrogen and oxygen only.



nitroglycerin

Which row shows the number of moles of the products formed when 4 mol of nitroglycerin decomposes?

	carbon dioxide	water	nitrogen	oxygen
A	8	8	6	6
B	8	8	12	12
C	12	10	6	1
D	12	10	12	2

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

A 10.0 g sample of H_2S was collected. How many H atoms are in this sample of H_2S? [L = Avogadro constant]

A $\dfrac{10.0 \times L \times 2}{34.1}$

B $\dfrac{L \times 34.1}{2 \times 10.0}$

C $\dfrac{2L}{10.0 \times 34.1}$

D $\dfrac{2 \times 10.0 \times 34.1}{L}$

3 Which of the following species would undergo the greatest deflection in an electric field?

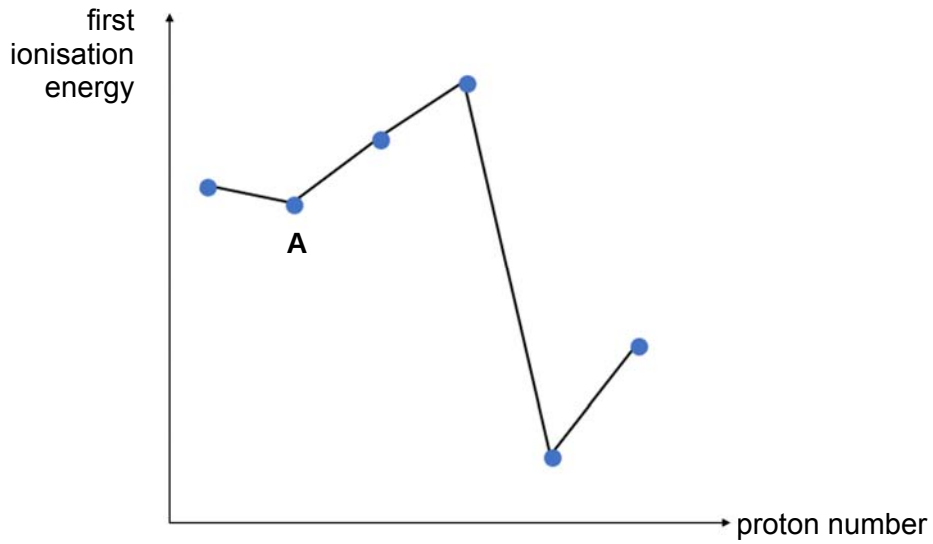
A $^{2}H_2^{+}$

B $^{7}Li^{2+}$

C $^{4}He^{+}$

D $^{9}Be^{3+}$

4 The diagram shows the variation of first ionisation energy with proton number for seven elements of consecutive proton numbers between 1 and 20.



Which of the following is element **A**?

A Mg
B Si
C S
D K

5 The boiling point of hexane is 69 °C while the boiling point of 2-methylpentane is 60 °C.

Which statement best explains the higher boiling point of hexane?

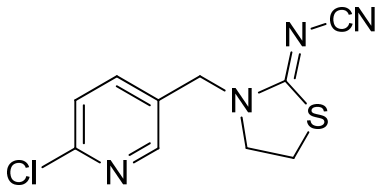
A Hexane has a higher density as it has better packing.

B Hexane has stronger intermolecular permanent dipole-permanent dipole interactions as it is more polar.

C Hexane has stronger intermolecular instantaneous dipole-induced dipole interactions as it has a larger surface area.

D Hexane has stronger intermolecular instantaneous dipole-induced dipole interactions as it has a larger number of electrons.

6 Thiacloprid is an insecticide widely used for pest control in agriculture.



thiacloprid

Which of the following shows the correct number of σ and π bonds in thiacloprid?

	σ bonds	π bonds
A	16	4
B	16	6
C	26	4
D	26	6

7 Which of the following statements can be explained by the presence of intermolecular hydrogen bonding?

1 HF is a weak acid.
2 NaC*l* readily dissolves in water.
3 Ice has a lower density than water.
4 The relative molecular mass of ethanoic acid in benzene is 120.

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

8 Which of the following shows the correct number of bonded electron pairs, number of lone pairs and the shape around each N atom in N_2H_4?

	number of bonded electron pairs around N atom	number of lone pairs around N atom	shape
A	3	0	trigonal planar
B	3	1	trigonal pyramidal
C	3	1	tetrahedral
D	4	0	tetrahedral

9 When 25.0 cm^3 of 0.70 mol dm^{-3} NaOH(aq) is added to 25.0 cm^3 of 0.70 mol dm^{-3} CH_3COOH(aq), the temperature of the mixture rise by 4.7 °C.

$$CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$$

Assume that the density and specific heat capacity of the final mixture are 1.0 g cm^{-3} and 4.18 J g^{-1} K^{-1} respectively.

What is the enthalpy change of neutralisation for the above process?

A +28.1 kJ mol^{-1}

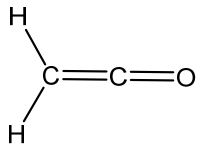
B +56.1 kJ mol^{-1}

C –28.1 kJ mol^{-1}

D –56.1 kJ mol^{-1}

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

Ethenone, CH_2CO, has the following structure.



ethenone

The reaction of gaseous ethenone with oxygen gas is given below.

$$CH_2CO(g) + 2O_2(g) \longrightarrow 2CO_2(g) + H_2O(g) \qquad \Delta H_r$$

What is the enthalpy change, ΔH_r, for this reaction?

A –632 kJ mol^{-1}

B –718 kJ mol^{-1}

C –762 kJ mol^{-1}

D –978 kJ mol^{-1}

11 Which statement about the order of a chemical reaction is correct?

A It is the sum of the number of species included in the rate equation.

B It is the sum of the number of species involved before the rate determining step.

C It is the sum of the powers of the concentrations of species included in the rate equation.

D It is the sum of the number of moles on the left-hand side of the balanced chemical equation.

12 In a kinetic study of the reaction D + E $\rightarrow$ products at constant temperature, the following data were obtained.

[D] / mol dm^{-3}	[E] / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
0.01	0.05	1.9×10^{-4}
0.02	0.05	3.9×10^{-4}
0.02	0.01	4.0×10^{-4}

If the rate constant doubles for each 10 ^{o}C rise in temperature, which of the following will give the greatest rate of reaction?

	[D] / mol dm^{-3}	[E] / mol dm^{-3}	temperature / ^{o}C
A	0.1	0.2	40
B	0.2	0.2	30
C	0.3	0.4	20
D	0.4	0.1	30

13 The initial rate of the reaction between aqueous H_2O_2 and acidified KI solution was found to be first order with respect to both H_2O_2 and I^-, and zero order with respect to H^+.

What is the units for the rate constant of this reaction?

A s^{-1}

B mol dm^{-3} s

C mol^{-1} dm^3 s^{-1}

D mol^{-2} dm^6 s^{-1}

14 Which of the following is correct for a system at dynamic equilibrium?

A The rates of both forward and backward reactions are zero.

B The concentration of reactants is equal to the concentration of products.

C There is no net change in the concentrations of the reactants and products.

D The rate constant of the forward reaction is equal to the rate constant of the backward reaction.

15 An equilibrium is represented by the following equation.

$$3F(g) + G(s) \rightleftharpoons 3J(g) \qquad \Delta H < 0$$

Which of the following is **incorrect** for the indicated changes?

	indicated changes	position of equilibrium	forward rate	backward rate
A	increase total pressure by compression	no change	increase	increase
B	increase temperature	shifts left	decrease	increase
C	adding catalyst	no change	increase	increase
D	adding more F	shifts right	increase	no change

16 Which of the following is a conjugate acid-base pair in the reaction below?

$$HSO_4^-(aq) + HPO_4^{2-}(aq) \rightleftharpoons SO_4^{2-}(aq) + H_2PO_4^-(aq)$$

	base	conjugate acid
A	HPO_4^{2-}	$H_2PO_4^-$
B	HPO_4^{2-}	HSO_4^-
C	HSO_4^-	HPO_4^{2-}
D	HSO_4^-	SO_4^{2-}

17 The ionic product of water, K_w, at two different temperatures are given below.

temperature / ^oC	K_w / $mol^2\ dm^{-6}$
25	1.00×10^{-14}
62	1.00×10^{-13}

Which statements are **incorrect** for pure water?

1 The self-ionisation of water is an exothermic process.
2 At 62 ^oC, pH = 14 − pOH.
3 At 62 ^oC, pH < pOH.

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

18 The first ionisation energies, in kJ mol^{-1}, of a sequence of elements of increasing proton (atomic number) are given below.

519 900 799 1090 1400 1310

Where is this sequence of elements likely to be located in the Periodic Table?

A Group 2
B Group 17
C from Li to N
D from N to Na

19 **L** and **M** are elements in the Periodic Table.

Element **L** forms an insoluble oxide.

Element **M** forms an acidic oxide that is unable to react with dilute NaOH.

What is the identity of elements **L** and **M**?

	L	**M**
A	Na	Si
B	Mg	S
C	A*l*	Si
D	Si	P

20 The table shows the results of experiments in which the halogens X_2, Y_2 and Z_2 were added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
X_2	no reaction	no reaction	no reaction
Y_2	X_2 formed	no reaction	Z_2 formed
Z_2	X_2 formed	no reaction	no reaction

Which of the following shows X_2, Y_2 and Z_2 in order of increasing oxidising strength?

A $X_2 \rightarrow Y_2 \rightarrow Z_2$

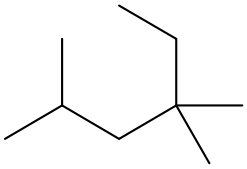
B $X_2 \rightarrow Z_2 \rightarrow Y_2$

C $Y_2 \rightarrow Z_2 \rightarrow X_2$

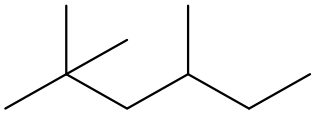
D $Y_2 \rightarrow X_2 \rightarrow Z_2$

21 What is the skeletal formula of 2,4,4-trimethylhexane?

A



B



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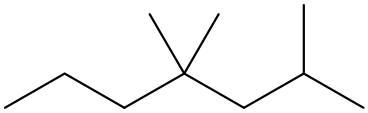

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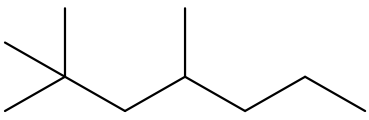


22 The diagram shows a reaction scheme involving 2-bromobutane.

$$C_4H_{10} \xrightarrow{X} CH_3CH(Br)CH_2CH_3 \xrightarrow{Y} C_4H_{10}O$$

2-bromobutane

What types of reaction are reaction X and reaction Y?

	X	Y
A	addition	substitution
B	substitution	substitution
C	addition	oxidation
D	substitution	oxidation

23 How many different alkenes, including *cis-trans* isomers, could be produced when $CH_3CH_2C(CH_3)BrCH_2CH_2CH_3$ is treated with hot ethanolic KOH?

A 2 **C** 4

B 3 **D** 5

24 An ester, W, of molecular formula $C_6H_{12}O_2$ undergoes acid hydrolysis to produce a carboxylic acid and an alcohol. The alcohol is found to have no reaction with hot acidified sodium dichromate(VI).

What could be the structural formula of ester W?

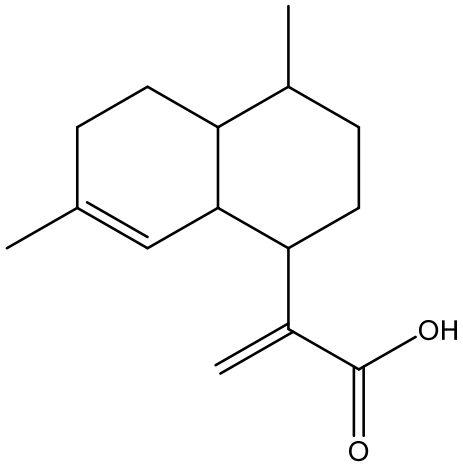
A $CH_3CO_2C(CH_3)_3$

B $(CH_3)_3CCO_2CH_3$

C $CH_3CH_2CO_2CH(CH_3)_2$

D $CH_3CH_2CO_2CH_2CH_2CH_3$

25 Artemisinic acid is a useful intermediate for making the anti-malarial drug, artemisin.



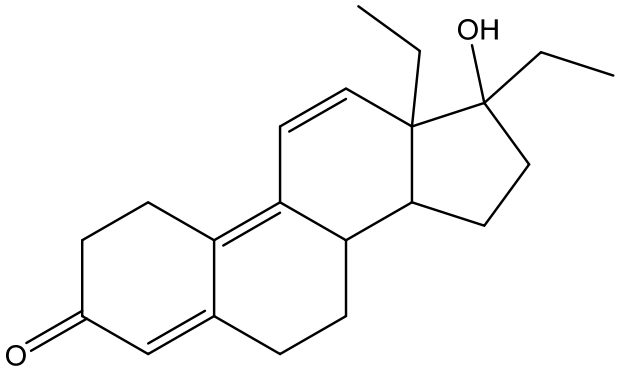
artemisinic acid

Which statements about artemisinic acid are correct?

1 It decolourises two moles of greenish-yellow chlorine.
2 It can be formed from the oxidation of an aldehyde.
3 It can be reduced by hydrogen gas.

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

26 THG is an anabolic steroid that mimics the effects of natural hormones, like testerone, found in the body. It promotes muscle growth and its misuse has led to many athletes being disqualified from international competitions, such as The Olympic Games.



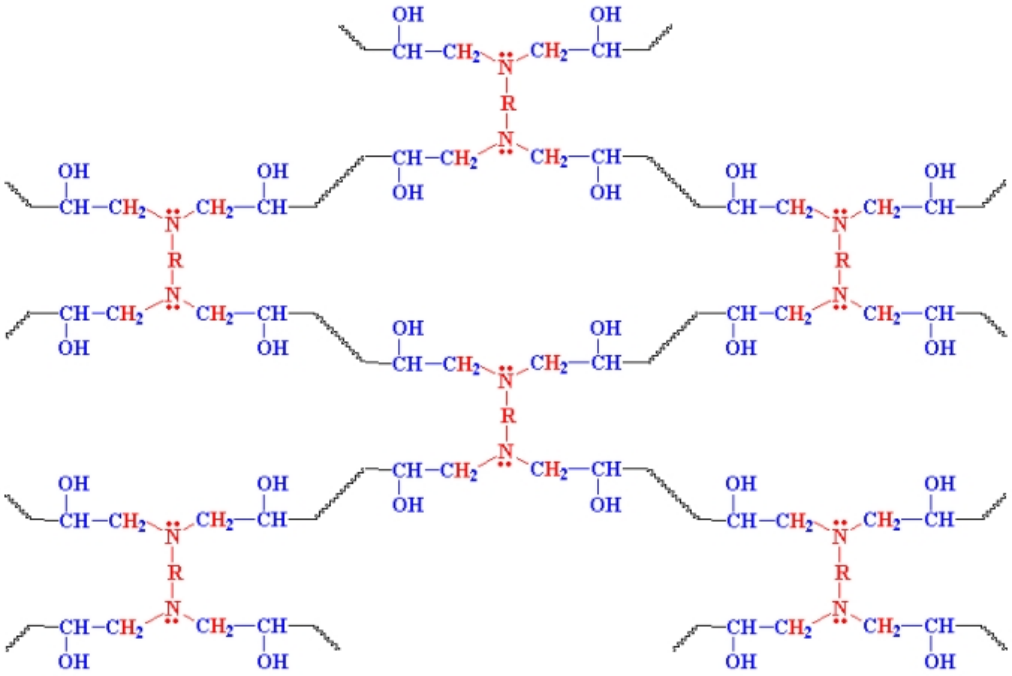
THG

Which statements about THG are correct?

1 It forms a C=C bond when heated with dilute sulfuric acid.
2 It reacts with sodium borohydride to form a secondary alcohol.
3 It is oxidised by potassium dichromate(VI) to a carboxylic acid.

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

27 Epoxy resins are renowned for their strong adhesive qualities. A segment of an epoxy resin is given below.



epoxy resin

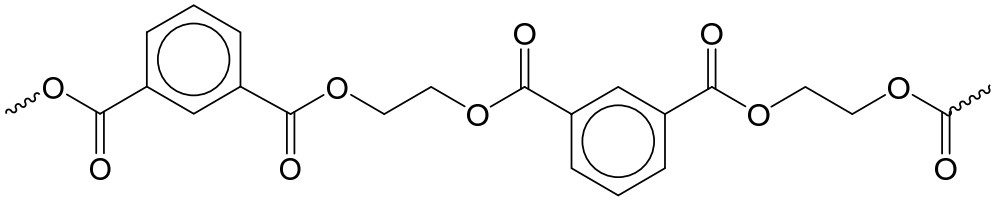
Which statements about an epoxy resin are correct?

1 It is a thermoset.
2 It contains the amide functional group.
3 It forms strong polar bonds with hydroxyl surfaces.

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

28 Football jerseys are commonly made from polymers, such as PET, as it is lightweight, durable and only absorbs 0.4% of its weight of water.

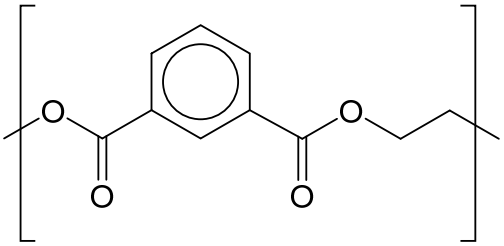
A polymer chain of PET is given below.



PET

Which are the monomers of PET?

A



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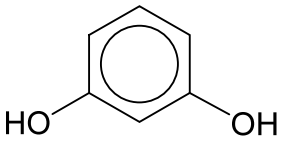

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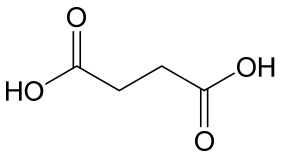

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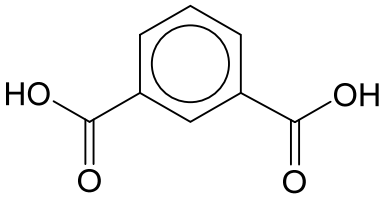

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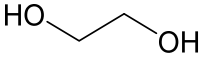
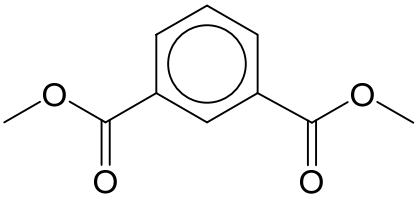


D



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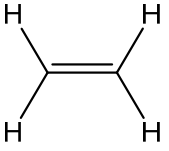


29 What is the maximum size, in at least one dimension, of a nanomaterial?

A 1×10^{-6} m

B 1×10^{-7} m

C 1×10^{-8} m

D 1×10^{-9} m

30 The honeycomb structure is commonly used to make blankets and is also found in catalytic converters and graphene.

Which statement about the honeycomb structure is **incorrect**?

A It allows air to be trapped.

B It will be easily deformed by pressure.

C Its large surface area to volume ratio increases catalytic efficiency.

D It has high tensile strength due to the network of strong covalent bonds within each layer.

– END OF PAPER –

RAFFLES INSTITUTION
2018 YEAR 6 PRELIMINARY EXAMINATION

Higher 1

CANDIDATE NAME

CLASS | INDEX NUMBER

CHEMISTRY 8873/02

Paper 2 Structured Questions **11 SEPTEMBER 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not open this question booklet until you are told to do so.

Write your name, class and index number in the spaces provided at the top of this page.
Write in dark blue or black pen in the spaces provided.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question.

For Examiner's Use		
Section A	**1**	**/ 13**
	2	**/ 5**
	3	**/ 20**
	4	**/ 11**
	5	**/ 11**
Section B (Please circle the question you have attempted)	**6**	**/ 20**
	7	**/ 20**
Total		**/ 80**

A Data Booklet is provided. Do not write anything in it.

You are reminded of the need for good English and clear presentation in your answers.

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

This document consists of **22** printed pages.

Section A

For examiner's use

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

1 (a) A student performed an experiment which involved two complexes of Co(II) ions and their colours are given below.

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}(aq)} + 4Cl^-(aq) \rightleftharpoons \underset{\text{blue}}{CoCl_4^{2-}(aq)} + 6H_2O(l) \qquad \Delta H > 0$$

(i) Write the K_c expression for this reaction and state its units.

units ……[2]

(ii) Solution **X** was prepared in which the initial concentrations of $Co(H_2O)_6^{2+}$ and Cl^- ions were 1.80 mol dm^{-3} and 4.00 mol dm^{-3} respectively. After equilibrium was reached, the concentration of $CoCl_4^{2-}$ ions was 0.92 mol dm^{-3}.

Calculate the value of K_c for this equilibrium.

value of K_c ……[2]

(iii) Two experiments were conducted using solution **X** and some experimental observations and deductions were given in Table 1.1.

Table 1.1

test	observations	equilibrium position	predominant ions present
① Test-tubes 1 and 2 contain solution **X**.	violet solution	near the centre	
② Place test-tube 2 in a beaker of hot water.	violet solution turns blue		

Complete Table 1.1. [2]

For examiner's use

(iv) Explain the observations in test ② using Le Chatelier's Principle.

……

……

……

……

……

……..[2]

(b) *Use of the Data Booklet is relevant to this question.*

The same student then performed a different experiment to investigate the solubility of iodine in aqueous solution and hexane.

$$I_2(aq) \rightleftharpoons I_2(hexane)$$

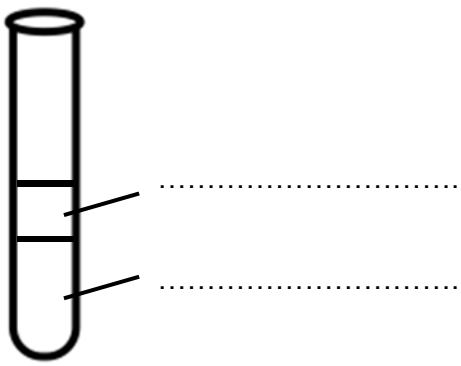
(i) State the colour of iodine in

aqueous solution …….

hexane ……. [1]

(ii) Hexane was added to a test-tube containing iodine dissolved in water and the mixture was shaken well for 10 seconds and allowed to settle. Two immiscible layers were observed.

Given that the densities of hexane and water are 0.655 g cm^{-3} and 1.00 g cm^{-3} respectively, label the colour of the two layers in this test-tube and explain your answer.



…….

…….

explanation ……..

……[1]

For examiner's use

(iii) Explain why iodine is more soluble in hexane than in water.

……

……

……

……[2]

(iv) Iodine can form the tri-iodide ion, I_3^-, with potassium iodide according to the reaction as shown.

$$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$$

The tri-iodide ion is soluble in water. Explain why this is so.

……

……[1]

[Total: 13]

For examiner's use

2 Poly(ethene) exists in two different forms, namely the low density poly(ethene) (LDPE) which has lots of side chains, and the high density poly(ethene) (HDPE), which has fewer and shorter side chains.

(a) Explain, with the aid of suitable diagrams, why the presence of fewer and shorter side chains results in high density poly(ethene).

LDPE	HDPE

explanation ……

……..

……..

…….[2]

(b) The manufacture of Lego bricks uses polymers which are commonly made from crude oil. These polymers are inert, very durable and less likely to fade in colour.

Explain why the disposal of such polymers is an environmental concern and suggest a strategy to overcome this problem.

explanation ……

……..

strategy ……..

……..[2]

(c) Much research has been done to promote the use of alternative starting materials instead of crude oil. Recently, Lego has started using poly(ethene) derived from sugar cane.

The ethanol in sugar cane is converted to ethene as shown in the reaction below.

$$CH_3CH_2OH \longrightarrow CH_2{=}CH_2 + H_2O$$

Name the type of reaction.

…….[1]

[Total: 5]

For examiner's use

3 (a) The element oxygen can exist as a number of isotopes.

Table 3.1

isotopic species	protons	neutrons	electrons	electronic configuration
$^{16}_{8}O$				$1s^2$
		10	8	$1s^2$

Complete Table 3.1. [2]

(b) The Haber-Weiss reaction generates highly reactive free radicals from H_2O_2.

A free radical is formed when the O–O covalent bond in H_2O_2 breaks. Explain, with the aid of a 'dot-and-cross' diagram, why the free radical is highly reactive.

explanation ……..……..[2]

(c) Hydrogen peroxide can undergo disproportionation reaction in the presence of the Fe^{2+} catalyst.

$$H_2O_2 \longrightarrow H_2O + \tfrac{1}{2}O_2 \qquad \Delta H = -196.1 \text{ kJ mol}^{-1}$$

The uncatalysed reaction has an activation energy of +49 kJ mol^{-1}.

(i) Using the data provided, draw a labelled energy profile diagram for the uncatalysed reaction on Fig 3.2.

Fig 3.2

[2]

For examiner's use

(ii) Explain what is meant by the term *activation energy*.

……

……[1]

(iii) With the aid of a Boltzmann distribution curve, explain the effect of a catalyst on the rate of reaction.

explanation ……..

……...

……

……

……

……

……

……

……[3]

For examiner's use

(d) The Harcourt and Esson reaction involves hydrogen peroxide and acidified potassium iodide.

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \longrightarrow 2H_2O(l) + I_2(aq)$$

The rate of reaction can be followed by measuring the concentration of H_2O_2 remaining at various times. The following table shows how $[H_2O_2]$ varies as the reaction proceeds.

time / s	0	100	200	300	400	500	600	700
$[H_2O_2]$ / mol dm^{-3}	0.030	0.024	0.019	0.015	0.012	0.010	0.0080	0.0060

(i) Plot a graph of $[H_2O_2]$ against time on Fig 3.1. [1]

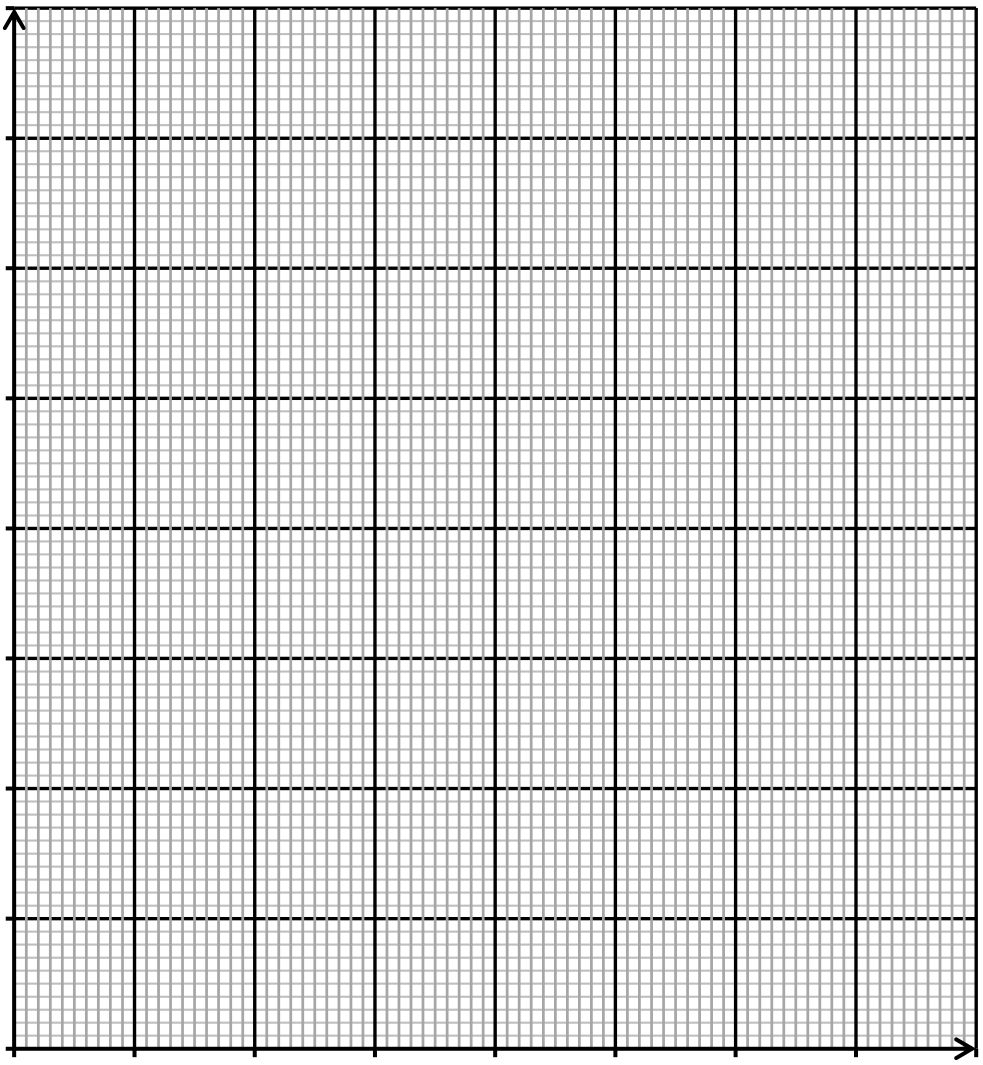


Fig 3.1

Use Fig 3.1 for **(d)(ii)** and **(d)(iii)**. By showing all your working and drawing clearly any construction lines on your graph, determine

For examiner's use

(ii) the order of reaction with respect to $[H_2O_2]$,

order of reaction …… [2]

(iii) the initial rate, in mol dm^{-3} s^{-1}.

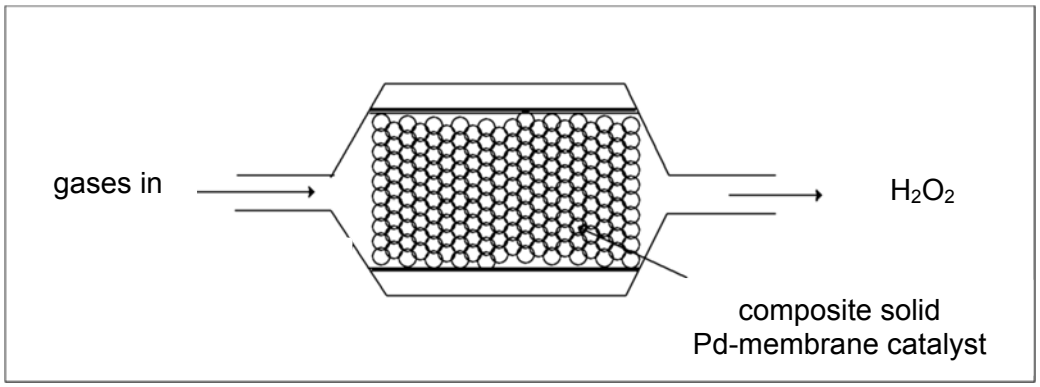
initial rate …… mol dm^{-3} s^{-1} [1]

For examiner's use

(e) H_2O_2 is in high demand in chemical industries as it is considered an environmentally-friendly oxidising agent.

Industries have been finding ways to produce H_2O_2 in a more economical manner by direct oxidation of H_2 with O_2.

In recent times, a novel composite solid palladium membrane catalyst for the direct oxidation of H_2 to H_2O_2 has been used.



(i) Explain why it is environmentally-friendly to use H_2O_2 as an oxidising agent.

……[1]

(ii) Write a balanced equation for the direct oxidation of H_2 to H_2O_2.

……[1]

(iii) State the type of catalyst involved in the direct oxidation of H_2 to H_2O_2.
Describe how this type of catalyst speeds up the gaseous reaction.

type of catalyst ……..

……

……

……

……

……

……

……[4]

[Total: 20]

For examiner's use

4 (a) (i) Describe the reactions of the chlorides of magnesium, aluminium and phosphorus with water.

Include the approximate pH value of any resulting solutions and write equations for any reactions that occur.

……

……

……

……

……

……

……

……

……

……

……

……[4]

(ii) Suggest what influence the type of bonding present in the chlorides of magnesium and phosphorus has on their reaction with water.

……

……

……

……

……[2]

For examiner's use

(b) Unlike aluminium, boron is a non-metal and share more similarities with carbon and silicon than with the other Group 13 elements.

(i) Like $SiCl_4$, BCl_3 undergoes hydrolysis to form compound **M** and white fumes.

Suggest the formula of compound **M** and write an equation for this reaction.

compound **M** ……

equation ……..……...[1]

(ii) Similar to carbon, boron nitride, BN, exists in a diamond-like form and in a graphite-like form.

In the diamond-like form, each nitrogen atom is bonded to four boron atoms, and each boron atom to four nitrogen atoms.

In the graphite-like form, each layer of BN consists of alternating boron and nitrogen atoms.

In the boxes provided below, draw the diamond-like and graphite-like structures of BN and predict a different physical property for each structure.

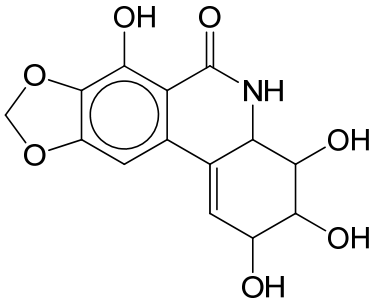
	diamond-like form	graphite-like form
structure		
physical property		

[4]

[Total: 11]

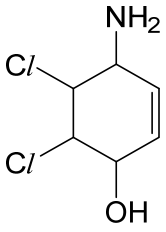
For examiner's use

5 Daffodils are bright yellow flowers which bloom in spring. When placed in a vase together with other flowers, they can cause premature wilting and death of these flowers. This is due to the toxic alkaloid compounds found in the daffodil mucilage. An example of the toxic alkaloid compounds found in daffodils is narciclasine.



narciclasine

Compound **P** is used in the synthesis of narciclasine.



P

(a) State the functional groups present in **P**.

……..……..….[3]

(b) Use the table of characteristic infra-red absorption frequencies in the *Data Booklet* to answer this question.

Infra-red absorptions can be used to identify functional groups in organic compounds. For example, carbonyl compounds show absorption at 1670 – 1740 cm^{-1}.

Use the table to identify an infra-red absorption range that will be shown by

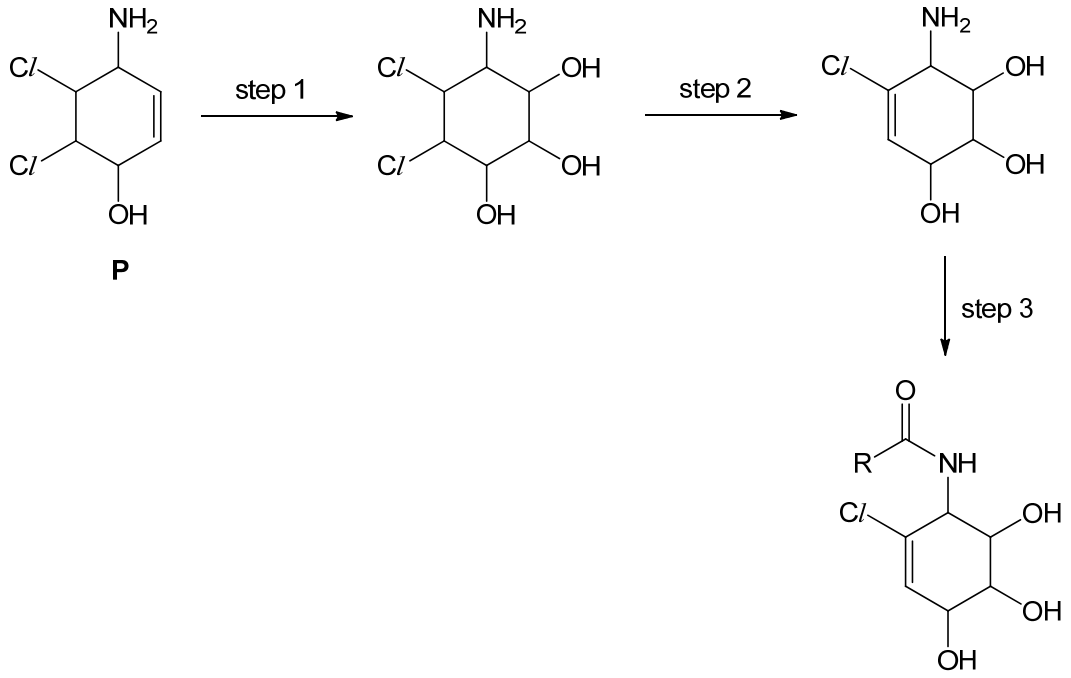
(i) narciclasine but not by **P**

…… cm^{-1}

(ii) **P** but not by narciclasine

…… cm^{-1} [2]

The following shows part of the synthesis of narciclasine from compound **P**.



P

(c) **(i)** Step 1 involves the oxidation of **P**.
Write a balanced equation for this reaction using the [O] notation.

……[1]

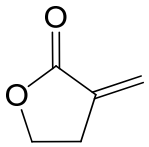
(ii) State the reagents and conditions for steps 2 and 3.

step 2: ……..

step 3: ……[2]

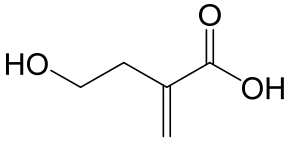
For examiner's use

(d) Tulip is one of the flowers with reduced vase life when placed together with daffodils. When handling tulips, skin contact with the tulip bulbs should be avoided to prevent 'tulips fingers', which is an allergic reaction caused by tulipalin A.



tulipalin A

Tulipalin A can be formed from compound **Q**.



Q

(i) State the type of reaction and the reagents and conditions required.

type of reaction ……

reagents and conditions ……..…[2]

(ii) Draw the displayed formula of the product formed when **Q** is heated with acidified aqueous $K_2Cr_2O_7$.

[1]

[Total: 11]

Section B

For examiner's use

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

6 (a) Iron is widely used in the manufacture of steel.

(i) Describe the structure and bonding in iron. Draw a diagram to illustrate your answer.

……..……..

……..……..

……[2]

(ii) By considering your answer to **(a)(i)**, state **two** physical properties that you would expect iron to possess. Explain why it possesses these properties.

property ……

explanation ……..

……

property ……

explanation ……..

……...[2]

For examiner's use

(b) Anaemia is a condition caused by a lack of iron in the body.

Iron tablets containing iron(II) sulfate, $FeSO_4$, are administered to patients suffering from anaemia. The amount of iron(II) sulfate in the tablets can be determined titrimetrically using acidified potassium manganate(VII), $KMnO_4$.

In an experiment, five iron tablets were crushed and dissolved in dilute sulfuric acid. This solution was made up to 250 cm^3 with deionised water.

25.0 cm^3 of the diluted solution required 27.55 cm^3 of 0.005 mol dm^{-3} acidified potassium manganate(VII) for complete reaction.

(i) Write a balanced equation for the overall reaction between Fe^{2+} and MnO_4^-.

……[1]

(ii) Calculate the amount, in moles, of iron(II) sulfate present in the original 250 cm^3 solution.

[3]

(iii) Hence, calculate the mass of iron(II) sulfate present in one tablet.

[2]

(iv) A student decided to repeat the experiment, but dissolved the crushed tablets in hydrochloric acid instead.

State, with reasoning, what effect this will have on the volume of acidified $KMnO_4$ required for complete reaction and on the calculated mass of $FeSO_4$ in one tablet.

……

……

……

……[2]

For examiner's use

(c) The melting points of GeO_2 and SeO_3 are 1115 °C and 118 °C respectively.

(i) By considering the melting points of the oxides and the positions of Ge and Se in the Periodic Table, suggest the structure and type of bonding present in each of the oxides.

……..……..

……

……..……..

……..……[2]

(ii) SeO_3 can react with either sodium hydroxide or hydrochloric acid. Write a balanced equation for its reaction with either hydrochloric acid or sodium hydroxide.

……..[1]

(d) Ethanol can be used as a fuel. Most existing car engines can run on blends of 15% ethanol and 85% gasoline.

Ethanol is commonly produced by the fermentation of glucose, $C_6H_{12}O_6$.

(i) Calculate the average oxidation number of carbon in glucose.

[1]

(ii) Write a balanced equation for the disproportionation reaction of glucose to produce ethanol and carbon dioxide only, by using oxidation numbers or otherwise.

……..……....[1]

(e) Gasoline contains a mixture of alkanes, including octane, $CH_3(CH_2)_6CH_3$.

(i) Write a balanced equation, including state symbols, for the complete combustion of liquid octane under standard conditions.

……..……..…..[1]

(ii) Some relevant standard enthalpy change of formation values, $\Delta H_f^{\ominus}$, are given in Table 6.1. Using your answer to **(e)(i)** and the data in Table 6.1, calculate the standard enthalpy change of combustion of liquid octane.

For examiner's use

Table 6.1

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_3(CH_2)_6CH_3(l)$	–249.7
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8

standard enthalpy change of combustion of octane……[2]

[Total: 20]

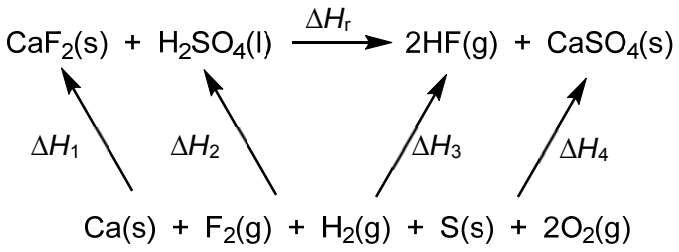
For examiner's use

7 (a) Hydrofluoric acid, HF, can be manufactured by treating calcium fluoride, CaF_2, with concentrated sulfuric acid, H_2SO_4.

(i) Draw a 'dot-and-cross' diagram to show the bonding in H_2SO_4. State the shape of the molecule around the S atom.

shape of molecule around the S atom .....[2]

(ii) The diagram below shows an energy cycle involving the reaction of calcium fluoride with concentrated sulfuric acid.



ΔH_1 = –1220 kJ mol^{-1}

ΔH_2 = –814 kJ mol^{-1}

ΔH_3 = –542 kJ mol^{-1}

ΔH_4 = –1434 kJ mol^{-1}

Using the energy cycle and data provided, calculate the

① enthalpy change of formation of gaseous hydrogen fluoride, ΔH_f,
② enthalpy change of the reaction, ΔH_r.

ΔH_f .....

ΔH_r .....[3]

For examiner's use

(b) Compared to other hydrogen halides, HF shows significantly different chemical and physical properties.

(i) By quoting relevant values from the *Data Booklet*, describe and explain the trend in thermal stability of the hydrogen halides HF, HC*l* and HBr.

……

……

……

……

……

……

……[3]

(iii) Calculate the pH of a 0.050 mol dm^{-3} solution of HC*l*.

[1]

(ii) With the aid of an equation, briefly explain why HF is a weak acid.

……

……

……[2]

(iv) A student proposed diluting a solution of HF so as to
① increase its acid dissociation constant, K_a and
② lower its pH value.
Explain if the student is correct.

……

……

……

……[2]

For examiner's use

(c) To standardise a solution of aqueous ammonia, a titration was carried out with 0.050 mol dm^{-3} solution of aqueous hydrochloric acid. During this titration, hydrochloric acid is added gradually from a burette until the end-point is reached.

(i) Write a balanced equation for the reaction of aqueous ammonia with aqueous hydrochloric acid.

……[1]

(ii) Suggest a suitable indicator for the titration and indicate the colour change at the end-point.

indicator ……

colour change ……[2]

(iii) 25.0 cm^3 of aqueous ammonia required 22.00 cm^3 of aqueous hydrochloric acid for complete reaction. Calculate the concentration of aqueous ammonia.

[1]

(iv) During the addition of the first 11.00 cm^3 of hydrochloric acid, the mixture is behaving as a buffer. Explain how the mixture is behaving as a buffer at this stage of the titration.
Include an equation in your answer.

……

……

……

……

……

……[3]

[Total: 20]

– END OF PAPER –

Suggested Answers for 2018 Y6 H1 Chemistry Preliminary Examination

Paper 1:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	A	D	C	C	D	D	B	D	D	C	D	C	C	B	A	D	C	C	B

21	22	23	24	25	26	27	28	29	30
A	B	D	A	A	A	B	C	B	B

Paper 2
Section A

1(a)(i)

$$K_c = \frac{[CoCl_4^{2-}]}{[Co(H_2O)_6^{2+}][Cl^-]^4} \quad \text{units} = mol^{-4}dm^{12}$$

1(a)(ii)

	$Co(H_2O)_6^{2+}(aq)$	$+ 4Cl^-(aq)$	$\rightleftharpoons$	$Co(Cl)_4^{2-}(aq)$	$+ 6H_2O(l)$
I	1.80	4.00		0	-
C	−0.92	−4(0.92)		+0.92	-
E	0.88	0.32		0.92	-

value of $K_c = \frac{(0.92)}{(0.88)(0.32)^4} = 99.7$

1(a)(iii)

test	obsn	eqm pos	predominant species present
①	violet soln	near the centre	mixture of pink $Co(H_2O)_6^{2+}$ ions and blue $CoCl_4^{2-}$ ions
②	violet soln turns blue	right	$CoCl_4^{2-}$ ions

1(a)(iv)

When test-tube 2 is placed in a beaker of hot water, the temperature of the solution increases. This causes the position of equilibrium to shift right, favouring the forward endothermic reaction.

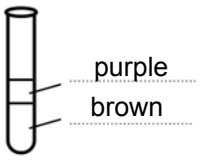
This is in accordance to Le Chatelier's principle as the system attempts to counteract the increase in temperature by absorbing heat.

Hence with the forward reaction favoured, the concentration of pink $Co(H_2O)_6^{2+}$ ions decreases, concentration of blue $CoCl_4^{2-}$ ions increases, causing the solution to turn from violet to blue.

1(b)(i)

iodine in aqueous solution — brown
iodine in hexane — purple

1(b)(ii)



explanation

Hexane has a lower density than water. Since iodine dissolves in hexane to give purple colour, the purple layer is the upper layer.

1(b)(iii)

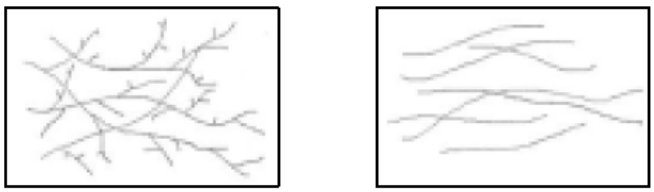
Iodine is non-polar and will form instantaneous dipole-induced dipole interactions with non-polar hexane molecules.

Iodine cannot form hydrogen bonds with polar water molecules.

1(b)(iv)

Tri-iodide ion can form ion-dipole interaction with water. (which is stronger than the hydrogen bonding in water)

2(a)



HDPE is largely unbranched / linear and allows for more efficient/close packing of the polymer chains. Hence there is more mass packed into the same volume.

2(b)

Either one of these explanations and strategies

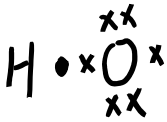
explanation	strategy
produced from crude oil, a non-renewable resource	use renewable resources
do not decompose/biodegrade	develop biodegradable polymers/ recycle polymers
produce toxic gases on burning	

2(c)
elimination

3(a)

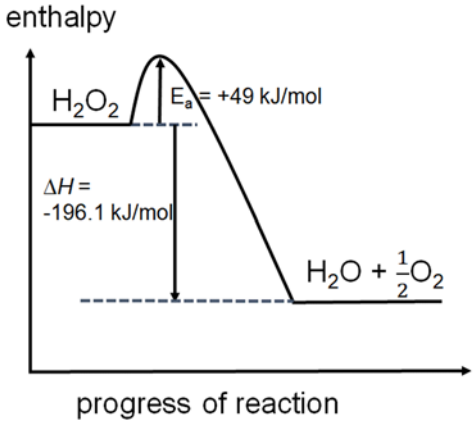
isotopic species	protons	neutrons	electrons	electronic configuration
$^{16}_{8}O$	8	8	8	$1s^2 2s^2 2p^4$
$^{18}_{8}O$	8	10	8	$1s^2 2s^2 2p^4$

3(b)



The free radical is highly reactive as it has a single unpaired electron.

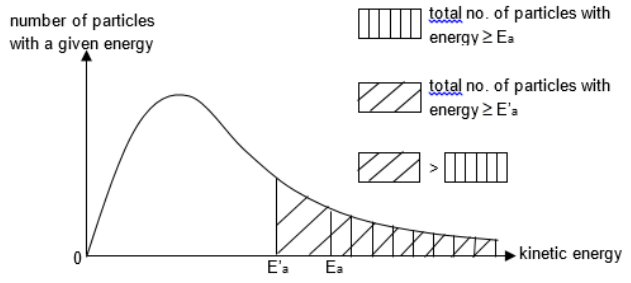
3(c)(i)



3(c)(ii)
The activation energy (E_a) of a reaction is the minimum amount of energy that the reactant particles must possess before their collisions can result in a reaction.

3(c)(iii)
In the catalysed reaction, since the activation energy is lower than that of the uncatalysed reaction, there is a greater proportion of reacting particles having energy greater than or equal to the activation energy than in the uncatalysed reaction.

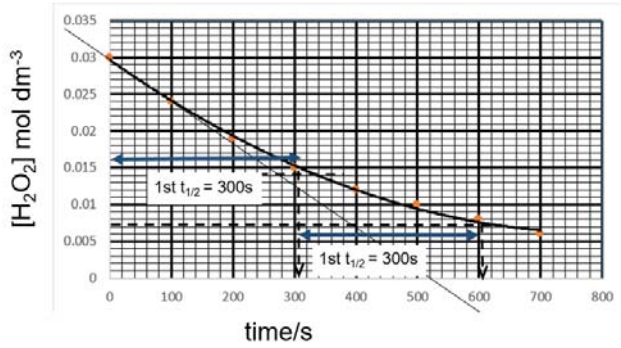
This is shown by the larger shaded area in the Maxwell-Boltzmann distribution curve.



Frequency of effective collision increases accordingly, and hence, the reaction rate increases.

Lower activation energy also results in the reaction having a larger rate constant, and hence, the reaction rate is increased.

3(d)(i)



3(d)(ii)
From the graph, 1st $t_{½}$ ≈ 2nd $t_{½}$ = 300 s
Hence, the reaction is first order wrt H_2O_2.

3(d)(iii)
Initial rate = –gradient of tangent to graph at time = 0
= 0.03 / 520 = 5.77 x 10^{-5} mol dm^{-3} s^{-1}

3(e)(i)
The product of oxidation is water which is clean/non-pollutants.

3(e)(ii)
$H_2 + O_2 \longrightarrow H_2O_2$

3(e)(iii)
type of catalyst: heterogeneous catalyst
(as the catalyst and the reactants are in different phases)

For heterogeneous catalysis to occur, the reactant molecules need to be readily adsorbed onto the catalyst surface, i.e. the formation of weak bonds between the catalyst surface active sites and the reactant molecules.

The adsorption of the reactant molecules at the catalyst surface increases the reaction rate because it

1. weakens the covalent bonds within the reactant molecules, thereby reducing the activation energy for the reaction.

2. increases the concentration of reactant molecules at the catalyst surface and allows the reactant molecules to come into close contact with proper orientation for reaction.

4(a)(i)
When $MgCl_2$ and $AlCl_3$ dissolves in water, the Mg^{2+} and Al^{3+} gets hydrated.

The hydrated Mg^{2+} undergoes slight hydrolysis to give H_3O^+. The resultant solution has a pH ≈ 6.5.
$MgCl_2 + 6H_2O \rightarrow [Mg(H_2O)_6]^{2+} + 2Cl^-$
$[Mg(H_2O)_6]^{2+} + H_2O \rightleftharpoons [Mg(OH)(H_2O)]^+ + H_3O^+$

The hydrated Al^{3+} undergoes appreciable hydrolysis to give H_3O^+. The resultant solution has a pH ≈ 3.

$AlCl_3 + 6H_2O \rightarrow [Al(H_2O)_6]^{3+} + 3Cl^-$
$[Al(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H_3O^+$

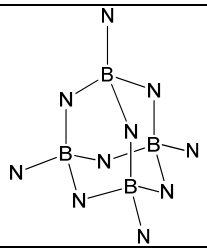
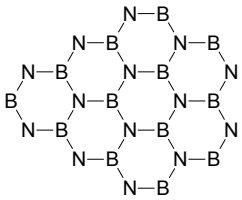
PCl_5 hydrolyses in water to give H_3O^+ as shown. The resultant solution has a pH ≈ 2.
$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$

4(a)(ii)
Ionic chlorides such as $MgCl_2$ dissolve in water to give an almost neutral (slightly acidic) solution

Covalent chlorides such as PCl_5 hydrolyse in water to give an acidic solution.

4(b)(i)
$BCl_3 + 3H_2O \rightarrow B(OH)_3 + 3HCl$
M
(also accept: $2BCl_3 + 3H_2O \rightarrow B_2O_3 + 6HCl$)

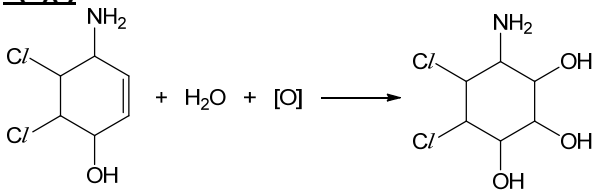
4(b)(ii)

	diamond-like form	graphite-like form
structure		
physical property	• high m.p./b.p • or does not conduct electricity • or hard	• conducts electricity • or high m.p./b.p. • or soft

5(a)
alkene, 2° alcohol, 1° amine, chloroalkane (any 3)

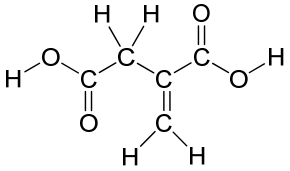
5(b)(i)
1640 – 1690 cm^{-1} (or 1475 – 1625 cm^{-1})

5(b)(ii)
700 – 800 cm^{-1}

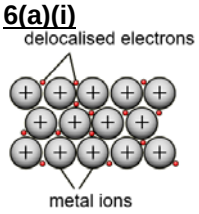
5(c)(i)

P

5(c)(ii)
step 2: ethanolic NaOH, heat
step 3: RCOOH, DCC

5(d)(i)
type of reaction: condensation
reagents and condns: (catalytic) conc H_2SO_4, heat

5(d)(ii)


Section B

6(a)(i)


Iron exists as a giant metallic structure with strong electrostatic attraction / metallic bonds between positively charged iron ions and delocalised electrons.

6(a)(ii)
property: good electrical conductivity
explanation: presence of mobile charge carriers (delocalised electrons) in metallic structure.

property: high melting point
explanation: A large amount of energy is needed to break the strong electrostatic attraction between positively charged iron ions and delocalised electrons.

6(b)(i)
$5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

6(b)(ii)
In 25 cm^3 of solution
Amt of MnO_4^- = $\frac{27.55}{1000}$ x 0.005 = 1.3775 x 10^{-4} mol
Amt of $FeSO_4$ = Amt of Fe^{2+}
= 5 x 1.3775 x 10^{-4} = 6.8875 x 10^{-4} mol

In 250 cm^3 of solution
Amt of $FeSO_4$ = 10 x 6.8875 x 10^{-4} = 6.89 x 10^{-3} mol

6(b)(iii)
Mass of $FeSO_4$ in 5 tablets
= 6.8875 x 10^{-3} x 151.9 = 1.046 g

Mass of $FeSO_4$ in 1 tablet = 1.046 ÷ 5 = 0.209 g

6(b)(iv)
As $KMnO_4$ will oxidise Cl^- to Cl_2.
- volume of $KMnO_4$(aq) required for complete reaction is larger
- calculated amount of $FeSO_4$ in each tablet will be larger than actual
- calculated mass of $FeSO_4$ in each tablet will be larger than actual.

6(c)(i)
From its high melting point and position of Ge in the Periodic Table (diagonal relationship with A*l*), GeO_2 has a giant ionic structure with strong ionic bonds between Ge^{4+} and O^{2-} ions. **(or GeO_2 is giant covalent)**

From its low melting point and position of Se in the Periodic Table, SeO_3 has a simple covalent structure with weak instantaneous dipole-induced dipole interactions between molecules.

6(c)(ii)
$SeO_3(s) + 2NaOH(aq) \longrightarrow Na_2SeO_4(aq) + H_2O(l)$

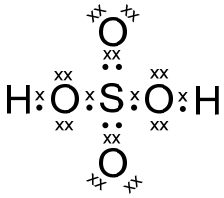
6(d)(i)
Let x be the average oxidation number of C.
$6x + 12(+1) + 6(-2) = 0 \rightarrow x = 0$

6(d)(ii)
Average O.N. of C in ethanol = –2
O.N. of C in CO_2 = +4
There are 2 C atoms in ethanol and 1 C atom in CO_2
$\rightarrow C_2H_5OH \equiv CO_2$
$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$

6(e)(i)
$CH_3(CH_2)_6CH_3\ (l) + 12.5\ O_2(g) \longrightarrow 8CO_2(g) + 9H_2O(l)$

6(e)(ii)
$\Delta H_{rxn}^{\ominus} = \Sigma n\Delta H_f^{\ominus}(\text{pdts}) - \Sigma m\Delta H_f^{\ominus}(\text{rxts})$
$= [8(-393.5) + 9(-285.8)] - [1(-249.7) + 12.5(0)]$
$= -5470\ \text{kJ mol}^{-1}$ (3 sf)

7(a)(i)



It is tetrahedral around the S atom.

7(a)(ii)
ΔH_f of HF = ½ (–542) = –271 kJ mol^{-1}

By Hess' Law,
$\Delta H_r = \Delta H_3 + \Delta H_4 - \Delta H_1 - \Delta H_2$
$= 1220 + 814 - 542 - 1434 = +58\ \text{kJ mol}^{-1}$

7(b)(i)
Thermal stability of the hydrogen halides (HX) is related to the H–X bond strength.

More endothermic bond dissociation energy suggests that the H–X bond is stronger and that HX is more thermally stable.

Since bond dissociation energy of H–X bond (in kJ mol^{-1}) decreases in the order:
H–F (+562) > H–C*l* (+431) > H–Br (+366)
thermal stability thus decreases in the order:
H–F > H–C*l* > H–Br

7(b)(ii)
Since HC*l* is a strong acid,
$[H^+] = [HCl] = 0.050\ \text{mol dm}^{-3}$
$pH = -\lg(0.050) = 1.30$

7(b)(iii)
HF is partially dissociated (or ionised) in aqueous solution.

$HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$

7(b)(iv)
(1) The K_a of the acid remains constant when it is diluted as it is a constant at constant temperature.

(2) Dilution will result in a lower $[H^+(aq)]$. Since $pH = -\lg[H^+]$, pH should increase with dilution.

7(c)(i)
$HCl(aq) + NH_3(aq) \longrightarrow NH_4^+(aq) + Cl^-(aq)$
or $H^+ + NH_3(aq) \longrightarrow NH_4^+(aq)$

7(c)(ii)
methyl orange
yellow to orange

7(c)(iii)
Amt of HC*l* = (22.00/1000)(0.050) = 1.10×10^{-3} mol
$[NH_3(aq)] = 1.10 \times 10^{-3} / (25.0/1000)$
$= 0.0440\ \text{mol dm}^{-3}$

7(c)(iv)
NH_3 and NH_4^+ is a buffer solution which resists changes in pH upon the addition of a small amount of acid or base.

Or it contains a large reservoir of weak base, NH_3, and its conjugate acid, NH_4^+.

When a small amount of H^+ ions is added to the solution, the following reaction occurs:
$NH_3(aq) + H^+(aq) \longrightarrow NH_4^+(aq)$

The presence of a large reservoir of unionised NH_3 molecules in the solution ensures that nearly all the added H^+ ions are removed.

Hence $[H^+]$ in the solution changes very little and the pH is kept approximately constant.