Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Thursday 21 May 2020

Morning (Time: 1 hour 30 minutes)	Paper Reference **8CH0/02**

Chemistry

Advanced Subsidiary
Paper 2: Core Organic and Physical Chemistry

Candidates must have: Scientific calculator Data Booklet Ruler	Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- For the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over

1/1/1/1/1/

Pearson

Answer ALL questions.

Some questions must be answered with a cross in a box ☒.
If you change your mind about an answer, put a line through the box ☒
and then mark your new answer with a cross ☒.

1 This question is about organic compounds containing fluorine and chlorine.

(a) The use of chlorofluorocarbons as refrigerants has ceased due to concerns about their effects on the ozone layer. One such compound is dichlorodifluoromethane.

Give the molecular formula of dichlorodifluoromethane.

(1)

....

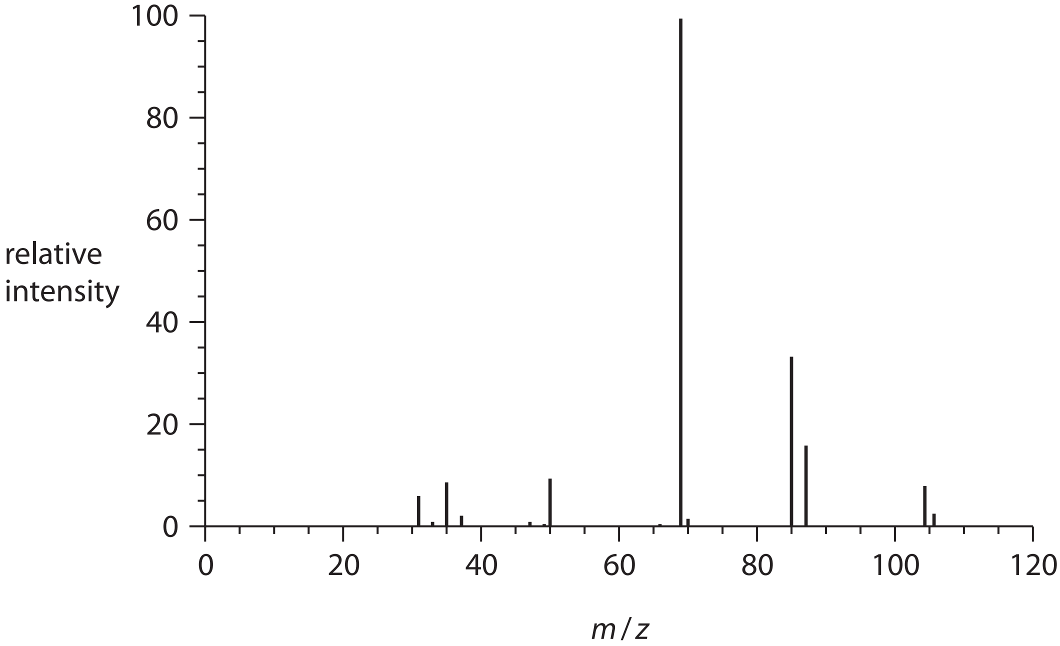
(b) (i) A different refrigerant contains 34.0% chlorine and 54.5% fluorine by mass, with the remainder carbon.

Calculate the empirical formula of this compound.

(3)

(ii) Use the mass spectrum to show that the empirical and the molecular formulae of this compound are the same.

(1)



....

....

....

(iii) Suggest the species responsible for the peak at $m/z = 69$.

(1)

P 6 2 3 0 7 A 0 3 2 8

Turn over ▶

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(c) Compounds containing carbon and fluorine but no chlorine can be used as refrigerants as they are not harmful to the ozone layer.
These can be made by the reaction of fluorine with alkanes or fluoroalkanes.
A refrigerant currently in use contains the compound trifluoromethane, CHF_3.

(i) Write the equation for the formation of trifluoromethane by the reaction of difluoromethane with fluorine. State symbols are not required.

(1)

(ii) The mechanism for this reaction is similar to that of the reaction between chlorine and methane.

Give the equations for the following steps in the mechanism for the reaction between fluorine and difluoromethane. Curly arrows are not required.

(3)

Initiation step

First propagation step

Second propagation step

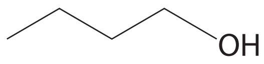
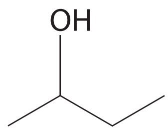
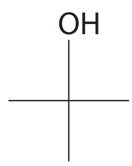
(Total for Question 1 = 10 marks)

2 This question is about alcohols and their reactions.

The table gives some of the names and skeletal formulae of isomers having the formula C_4H_9OH.

(a) Complete the table.

(2)

Name	Skeletal formula
	
butan-2-ol	
2-methylpropan-1-ol	
2-methylpropan-2-ol	

(b) (i) Some alcohols react with concentrated phosphoric acid to form alkenes.

What is the type of this reaction?

(1)

☒ **A** addition

☒ **B** elimination

☒ **C** oxidation

☒ **D** substitution

(ii) When butan-2-ol reacts with concentrated phosphoric acid, two stereoisomers are formed.

Explain what is meant by the term stereoisomers.

(2)

....

....

....

....

(iii) Draw the structures and give the names of the two stereoisomers.

(2)

Stereoisomer 1	Stereoisomer 2
Name:	Name:

(iv) Name this type of stereoisomerism.

(1)

....

(c) 2-methylpropan-2-ol may be formed by the reaction between 2-bromo-2-methylpropane and aqueous potassium hydroxide.

What is the role of the hydroxide ions in this reaction?

(1)

☒ **A** alkali

☒ **B** catalyst

☒ **C** electrophile

☒ **D** nucleophile

(d) (i) $CH_3CH_2CH_2CH_2OH$ reacts with the oxidising agent potassium dichromate(VI) in dilute sulfuric acid.

Two organic products can be formed, depending on the conditions.

Write a balanced equation for the formation of **one** of these products, giving its name and the condition required to achieve this product in high yield.

Use **[O]** in the equation to represent each oxygen atom from the oxidising agent.

(3)

Equation

Name ....

Condition ....

(ii) The colour of the solution at the end of the reaction in (d)(i) will be

(1)

☒ **A** brown

☒ **B** green

☒ **C** orange

☒ **D** yellow

(Total for Question 2 = 13 marks)

3 This question is about reaction kinetics.

(a) The best way to describe the activation energy of a reaction is

(1)

☒ **A** the average energy of the particles when they react

☒ **B** the difference in energy between the reactants and the products

☒ **C** the minimum energy required to make the particles collide

☒ **D** the minimum energy required for a reaction to occur

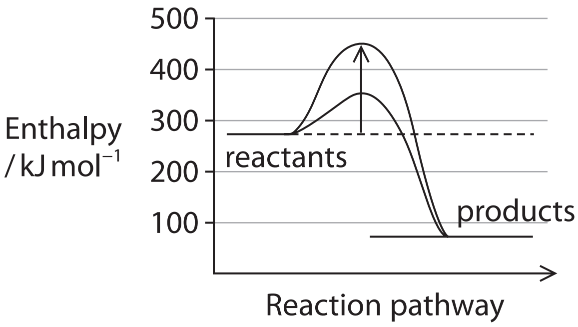
(b) The diagrams show two reaction profiles for the same reversible reaction involving gaseous reactants.

Shown on each diagram are the reaction profiles for the pathway without a catalyst and the pathway catalysed by a heterogeneous catalyst.

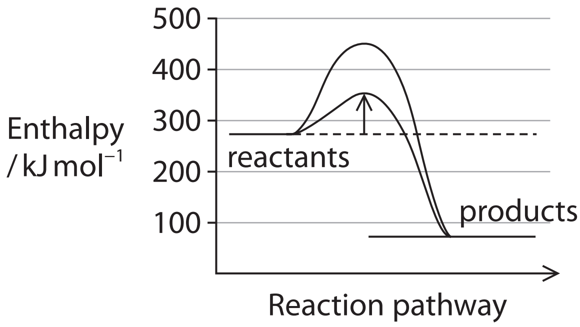
(i) In which diagram does the arrow represent the activation energy for the backward reaction when a catalyst is present?

(1)

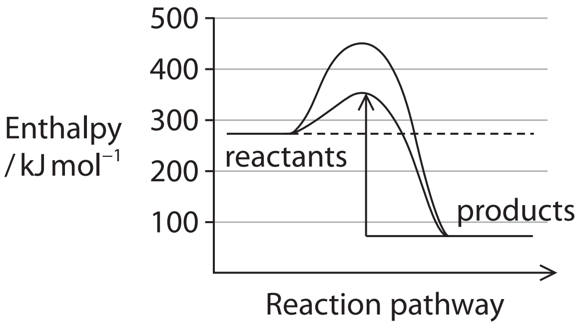
☒ **A**



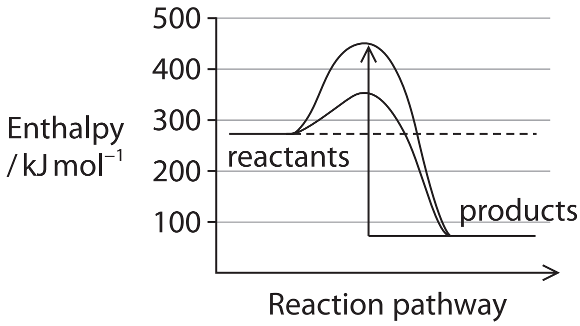
☒ **B**



☒ **C**

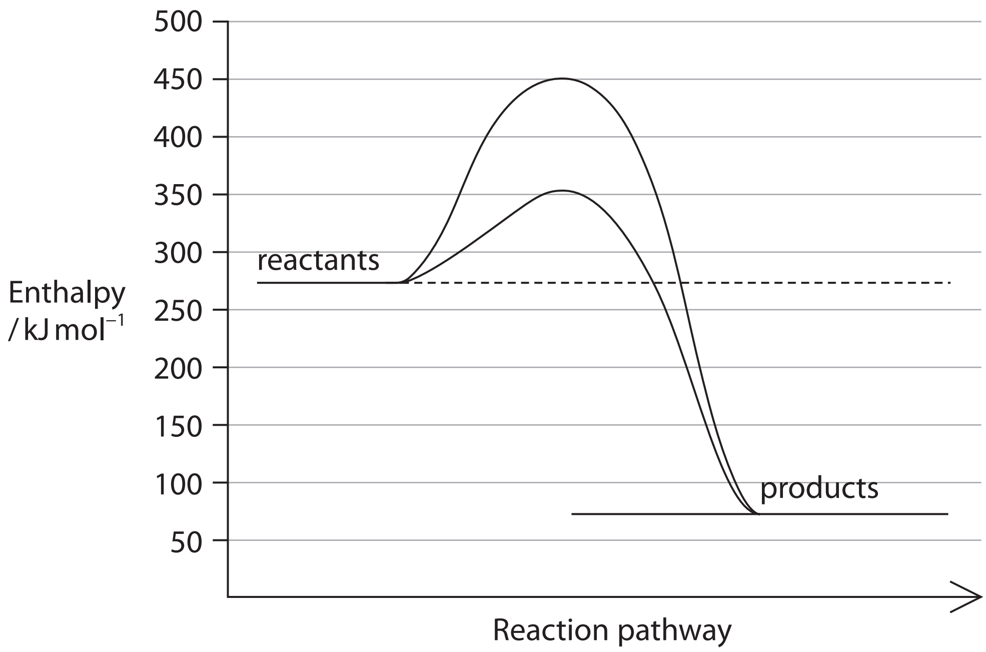


☒ **D**



(ii) Estimate, using the diagram, the **decrease** in the activation energy for the forward reaction when a catalyst is added.

(1)



☒ **A** 75 kJ mol^{-1}

☒ **B** 100 kJ mol^{-1}

☒ **C** 175 kJ mol^{-1}

☒ **D** 200 kJ mol^{-1}

(c) State why a **solid** (heterogeneous) catalyst is suitable for a reaction in the **gas** phase.

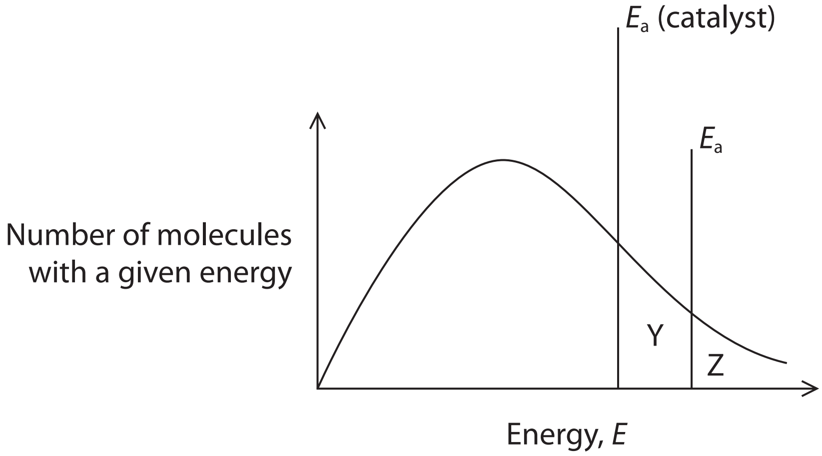
(1)

....

....

....

(d) The diagram shows a Maxwell-Boltzmann distribution of molecular energies for gaseous molecules.



(i) Which is the area of the graph corresponding to the number of molecules with sufficient energy to react when a catalyst is present?

(1)

☒ **A** Y

☒ **B** Y – Z

☒ **C** Y + Z

☒ **D** Z

(ii) Which would always result in a **decrease** in the number of molecules contained within area Y?

(1)

☒ **A** decreasing the temperature of the gas

☒ **B** increasing the pressure of the gas

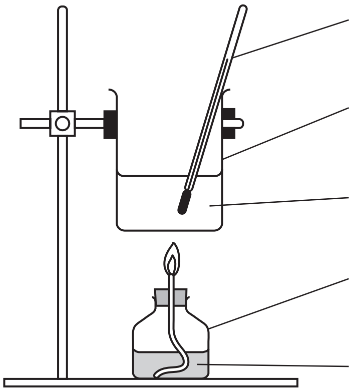
☒ **C** putting the gas in a smaller container

☒ **D** removing a quarter of the catalyst

(Total for Question 3 = 6 marks)

4 Methanol, CH_3OH, is a liquid fuel.

An experiment was carried out to determine the enthalpy change of combustion of liquid methanol.



The energy obtained from burning 2.08 g of methanol was used to heat 75.0 g of water.

The temperature of the water rose from 25.0 °C to 91.0 °C.

[Specific heat capacity of water = 4.18 J g^{-1} °C^{-1}]

(a) Use the data to calculate a value for the enthalpy change of combustion of one mole of methanol.

Give your answer to an appropriate number of significant figures and include a sign and units.

(4)

(b) Methanol can be synthesised from methane and steam by a process that occurs in two steps.

Step **1** $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206\,kJ\,mol^{-1}$

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

(i) Explain the effects of increasing the pressure on the yield of the products and on the rate of the reaction in Step **1**.

(4)

....

....

....

....

....

....

....

....

....

....

(ii) Step **2** is carried out at a compromise temperature of 500 K.

Explain why 500 K is considered to be a compromise for Step **2** by considering what would happen at higher and lower temperatures.

(3)

....

....

....

....

....

....

....

(c) Calculate a value for the standard enthalpy change of combustion of gaseous methanol using the enthalpy change for Step **2** and the standard enthalpy change of combustion of gaseous carbon monoxide and of hydrogen.

Substance	Standard enthalpy change of combustion / $kJ\,mol^{-1}$
CO	–283
H_2	–286

(3)

(Total for Question 4 = 14 marks)

5 This question concerns iodine monochloride, ICl, a red-brown solid which melts at 27 °C to form a red-brown liquid.

Iodine monochloride is used in measuring unsaturation in organic compounds.

(a) Iodine monochloride gas can be produced by the reaction between iodine vapour and chlorine gas. The reaction is exothermic.

$$I_2(g) + Cl_2(g) \rightarrow 2ICl(g) \quad \Delta_r H = -30\,kJ\,mol^{-1}$$

The table shows bond energy values for the bonds in iodine and chlorine.

Calculate the value of the bond energy of the I—Cl bond using these data and the equation.

Bond	Energy / $kJ\,mol^{-1}$
I—I	151
Cl—Cl	243

(2)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

P 6 2 3 0 7 A 0 1 4 2 8

(b) Iodine monochloride is a polar molecule which adds rapidly to double bonds in a similar way to hydrogen chloride. This reaction can be used to determine the degree of unsaturation in oils.

(i) Add the dipole to a molecule of iodine monochloride.

(1)

I—Cl

(ii) Draw the mechanism for the addition of iodine monochloride to propene. You should include all curly arrows and relevant lone pairs and dipoles.

(3)

(c) (i) To determine the extent of unsaturation of an oil, 0.250 g of the oil was treated with 25.00 cm^3 of a 0.100 mol dm^{-3} ICl solution. Unreacted ICl reacted with excess potassium iodide solution, forming iodine according to the equation:

$$ICl + KI \rightarrow I_2 + KCl$$

The amount of iodine produced was measured by reacting the mixture with a solution of sodium thiosulfate, $Na_2S_2O_3$.

The iodine released reacted with 32.65 cm^3 of 0.100 mol dm^{-3} sodium thiosulfate solution in the mole ratio of 1 mol I_2 : 2 mol $Na_2S_2O_3$.

Calculate the number of moles of iodine monochloride which reacted with 0.250 g of the oil.

(3)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

(ii) Unsaturation in oils is measured using a scale called 'Iodine number'.
This is the mass of iodine which will react with 100 g of the oil.
Because iodine adds very slowly to double bonds, the reaction of iodine monochloride is used instead.

Given that 1 mol of I_2 is equivalent to 1 mol of ICl, use your answer in (c)(i) to calculate the mass of iodine that would react with 100 g of oil and hence identify the unsaturated oil from the list of possible oils and their iodine numbers.

Oil	Iodine number
cocoa butter	35–40
coconut oil	7–10
cod liver oil	145–180
palm oil	44–51
peanut oil	84–106

(2)

(iii) Give a reason why the reaction of iodine monochloride is significantly faster than the reaction of iodine.

(1)

....

....

....

(Total for Question 5 = 12 marks)

BLANK PAGE

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

P62307A01828

6 Aqueous hydrogen peroxide decomposes according to the following equation.

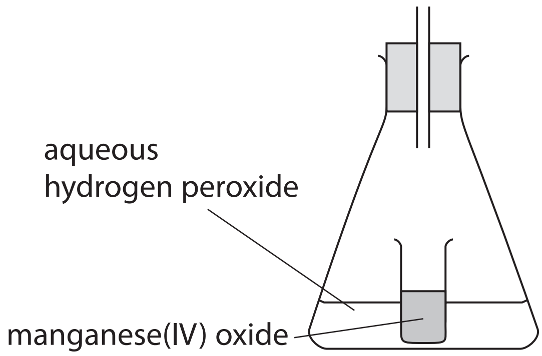
$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The decomposition is catalysed by manganese(IV) oxide.

This can be investigated by measuring the volume of oxygen produced at various times as the reaction proceeds. Part of the apparatus used in the experiment is shown. The manganese(IV) oxide is placed in a small glass container, which is then tipped over to start the reaction. A stop clock is started at the same time.

(a) Complete the diagram to show how the gas can be collected **and** its volume measured, labelling the apparatus used.

(2)

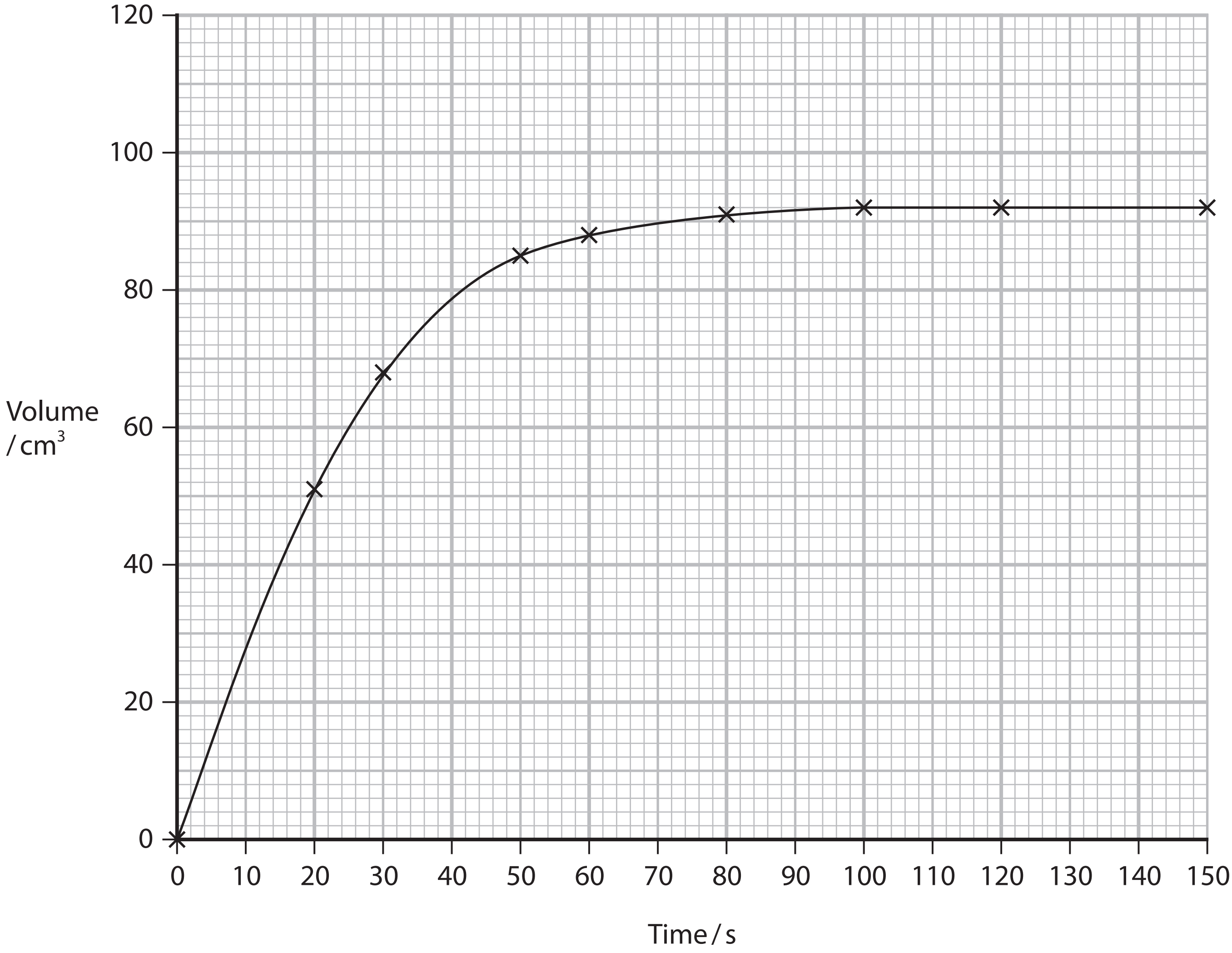


P 6 2 3 0 7 A 0 1 9 2 8

Turn over

(b) An experiment was carried out using 0.25 g of manganese(IV) oxide granules and 50 cm^3 of aqueous hydrogen peroxide of concentration 0.16 mol dm^{-3}. The results are shown in the table and plotted on a graph.

Time / s	0.0	20.0	30.0	50.0	60.0	80.0	100	120	150
Volume of O_2 / cm^3	0	51	68	85	88	91	92	92	92



(i) The rate of reaction may be assumed to be approximately constant up to the first volume measurement (20.0 s in this experiment).

Use this approximation to calculate the initial rate of this reaction, giving the **units** with your answer.

(1)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

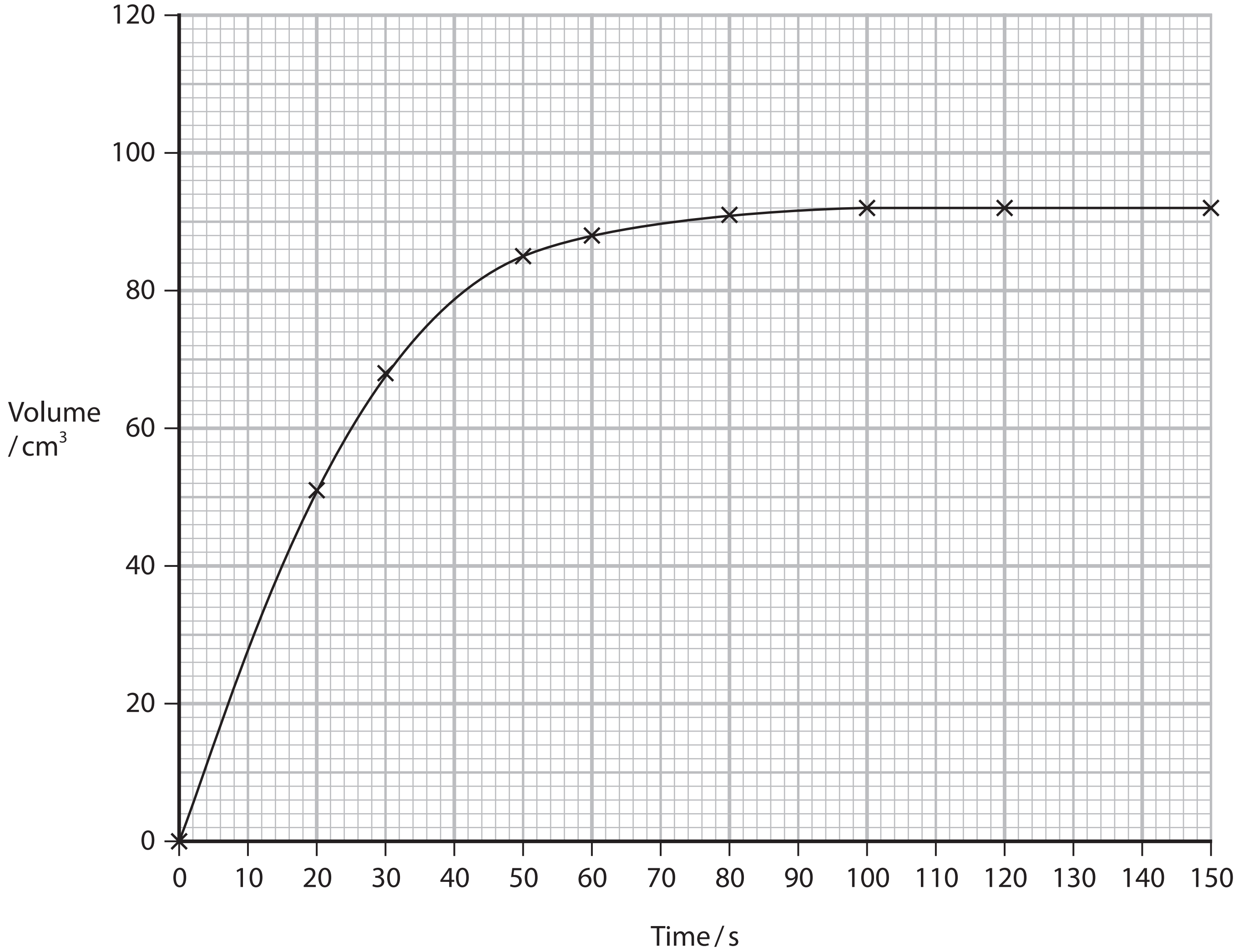
(ii) Draw a tangent at 40 s on the graph on Page 20 and use it to calculate the rate of reaction at this time.

(2)

(iii) The experiment was repeated on a different day when the laboratory was 20 °C warmer. The volume of oxygen was recorded for the same total time of 150 s.

Draw the line that you would expect to obtain in this experiment. Assume the pressure in the laboratory is the same. No calculation is required.

(2)



(iv) Explain, using collision theory, any differences between the line you have drawn and the original line of best fit.

(2)

(c) Catalysts are not used up during a reaction. Manganese(IV) oxide acts as a heterogeneous catalyst.

Describe in outline a method to show that the manganese(IV) oxide is not used up in the decomposition of hydrogen peroxide **and** that it still functions as a catalyst.

(4)

(Total for Question 6 = 13 marks)

BLANK PAGE

7 Halogenoalkanes react with water to produce alcohols and halide ions.

$$C_4H_9X + H_2O \rightarrow C_4H_9OH + X^- + H^+$$

(a) Test tube experiments can be carried out to investigate the relative rates of these substitution reactions.

The halogenoalkanes 1-chlorobutane, 1-bromobutane and 1-iodobutane can be used.

Some of the steps in these experiments are

- each halogenoalkane is added to a different tube containing 1 cm^3 of ethanol
- the test tubes are placed in the same beaker of hot water
- aqueous silver nitrate is added to each tube and the tubes are shaken
- a precipitate forms in each tube.

(i) State the purpose of adding ethanol to each of the test tubes.

(1)

....

....

....

(ii) Give **one** reason why the test tubes were put in the same beaker of hot water.

(1)

....

....

....

(iii) Give **one** reason why the test tubes were shaken after the addition of aqueous silver nitrate.

(1)

....

....

....

(b) (i) State how the halogen atom present in each halogenoalkane can be identified using observations from this experiment in (a).

(1)

....

....

....

....

....

....

(ii) Identify further reagents that can be added, including relevant observations, to confirm the identity of the halogen atom present in each halogenoalkane.

(2)

....

....

....

....

....

*(c) Outline the method for a test tube experiment, **which expands on the steps in (a)**, to investigate how the rate of the substitution reaction depends on whether the halogenoalkane is primary, secondary or tertiary.

Your experiment should test a series of isomeric bromoalkanes reacting with water.

Your plan should include

- the chemicals you will use
- an outline of how the experiment will be carried out
- the observations or measurements you will make and how you will interpret them.

(6)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 7 = 12 marks)

TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
1.0 **H** hydrogen 1																	4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12											27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
* Actinide series	232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103