Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson
Edexcel GCE

Centre Number | Candidate Number

Thursday 23 May 2019

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 ▶

2/2/1/1/1/

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 Some alkanes are used as fuels for transport. Crude oil, which is a mixture of hydrocarbons, is the major source of these alkanes. Crude oil is processed by fractional distillation, cracking and reforming.

(a) Fractional distillation produces fractions which contain molecules of a similar boiling temperature. Molecules containing six carbon atoms are found in both the petrol fraction and the higher boiling kerosene fraction.

(i) Identify, by name or structural formula, the unbranched alkane with six carbon atoms found in kerosene.

(1)

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(ii) Explain why **isomers** of the alkane in (a)(i) have lower boiling temperatures and so are found in the petrol fraction.

(3)

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(b) During cracking, carbon to carbon bonds are broken.

Explain the **two** major reasons for cracking hydrocarbons.

(3)

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(c) Which of the following changes to the proportions of organic molecules within a fraction results from the reforming process?

(1)

	Proportion of branched chain alkanes	Proportion of cyclic hydrocarbons
☒ **A**	decrease	decrease
☒ **B**	decrease	increase
☒ **C**	increase	decrease
☒ **D**	increase	increase

(Total for Question 1 = 8 marks)

2 This question is about organic compounds.

(a) Organic compounds can be grouped together in homologous series.

(i) Describe **two** characteristics of a homologous series.

(2)

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(ii) Name the homologous series to which propene belongs.

(1)

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(b) Propene can be converted into a mixture of 1-chloropropane and 2-chloropropane, in which 2-chloropropane is the major product.

(i) Give the reagent required for this reaction.

(1)

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(ii) What is the type and mechanism of the reaction in (b)(i)?

(1)

☒ **A** electrophilic addition

☒ **B** nucleophilic addition

☒ **C** electrophilic substitution

☒ **D** nucleophilic substitution

(c) 1-chloropropane and 2-chloropropane can be converted into compounds containing the nitrile functional group.

(i) Under appropriate conditions, 1-chloropropane can be converted into butanenitrile, $CH_3CH_2CH_2CN$.

Which is the reagent for this conversion?

(1)

☒ **A** ammonia

☒ **B** nitric acid

☒ **C** potassium cyanide

☒ **D** silver nitrate

(ii) Under appropriate conditions, 2-chloropropane can be converted into a structural isomer of butanenitrile.

State what is meant by the term 'structural isomer'.

(2)

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(iii) Give the displayed formula **and** systematic name of the isomer of butanenitrile formed in (c)(ii). You must show **all** the bonds.

(2)

Displayed formula

Name

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(Total for Question 2 = 10 marks)

3 This question is about enthalpy changes.

(a) (i) State what is meant by the term 'standard enthalpy change of combustion'.

(2)

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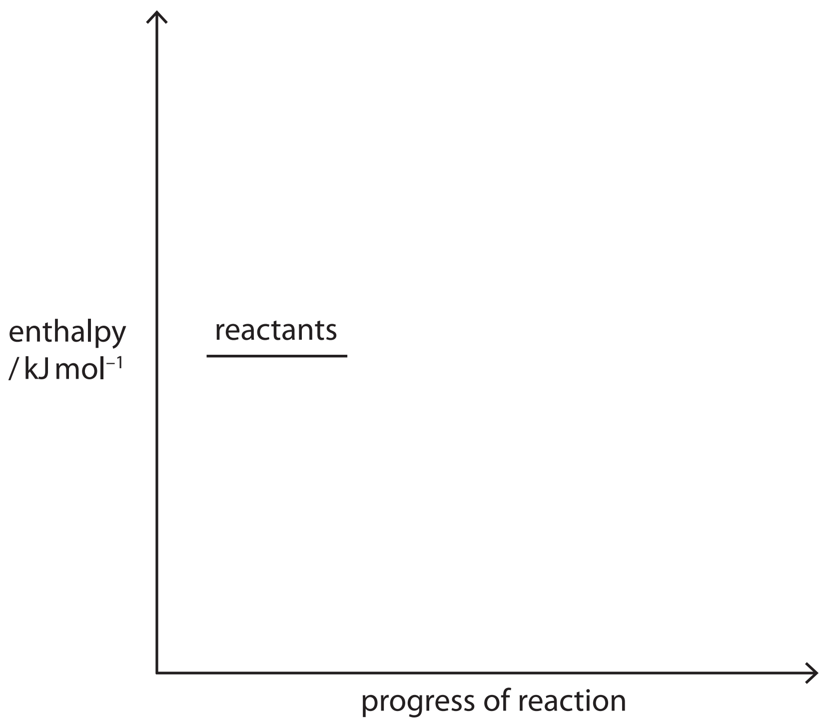
(ii) Write the equation, including state symbols, for the reaction that occurs when the standard enthalpy change of combustion of octane, $C_8H_{18}(l)$, is measured.

(2)

(iii) The standard enthalpy change of combustion of octane is –5 470 kJ mol^{-1}.

Complete the reaction profile diagram for the combustion of octane. Include labels showing the standard enthalpy change of combustion, $\Delta_c H^{\ominus}$, and the activation energy, E_a.

(2)



P 5 5 6 1 1 A 0 6 2 8

(b) Enthalpy changes of reactions which cannot be measured directly can be calculated using standard enthalpy changes of combustion.
The table shows some of these values.

Substance	$\Delta_c H^{\ominus}$ / kJ mol^{-1}
C(s)	−394
H_2(g)	−286
CH_4(g)	−890

Complete the Hess cycle and use it to calculate the standard enthalpy change for the following reaction.

(4)

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$

(c) The equations for the combination of gaseous atoms of carbon and hydrogen to form methane, CH_4, and propane, C_3H_8, are

$$C(g) + 4H(g) \rightarrow CH_4(g) \qquad \Delta H = -1652\,kJ\,mol^{-1}$$

$$3C(g) + 8H(g) \rightarrow C_3H_8(g) \qquad \Delta H = -3998\,kJ\,mol^{-1}$$

Calculate:

(i) the mean bond enthalpy of a C—H bond.

(1)

(ii) the mean bond enthalpy of a C—C bond.

(2)

(Total for Question 3 = 13 marks)

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4 Methanol is manufactured from a mixture of carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -90.8\,kJ\,mol^{-1}$$

(a) Give **two** characteristics of all reactions at equilibrium.

(2)

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(b) (i) How does the equilibrium yield of methanol change if the temperature is increased at constant pressure or the pressure increased at constant temperature?

(1)

	Equilibrium yield when temperature is increased	Equilibrium yield when pressure is increased
☒ **A**	decrease	decrease
☒ **B**	decrease	increase
☒ **C**	increase	decrease
☒ **D**	Increase	increase

(ii) Explain your answer to (b)(i).

(2)

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(c) Explain why, in the industrial process involving this reaction, a catalyst is used.

(2)

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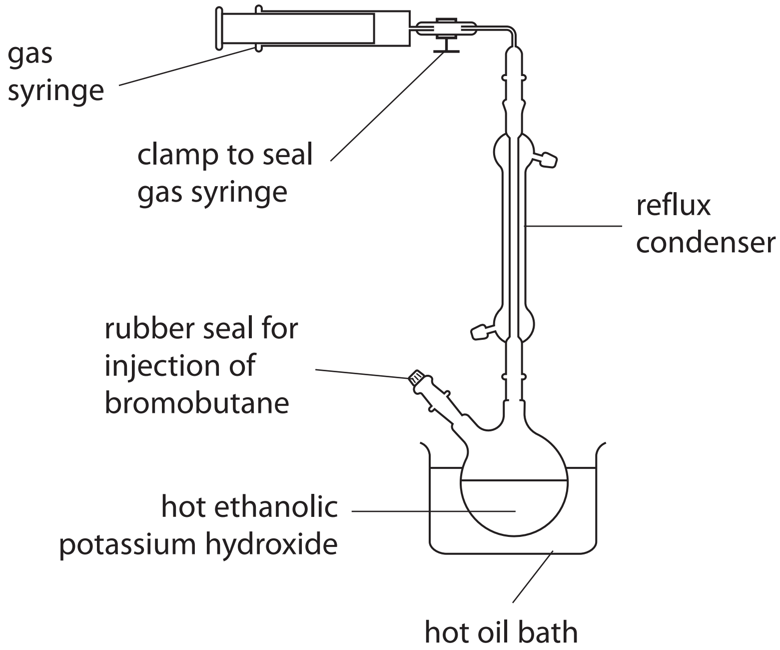
(Total for Question 4 = 7 marks)

5 Bromobutanes react with hot ethanolic potassium hydroxide solution to produce gaseous butenes.

$$C_4H_9Br + OH^- \rightarrow C_4H_8 + Br^- + H_2O$$

Apparatus



Procedure

- 0.0080 mol of liquid 1-bromobutane was injected into a round bottom flask containing hot ethanolic potassium hydroxide.
- After the reaction, the syringe was sealed using a clamp.
- The syringe was then removed from the apparatus and allowed to cool to room temperature (298 K).

Result

The final volume of but-1-ene collected was 22.0 cm^3.

(a) State the purpose of the condenser.

(1)

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(b) Describe a chemical test on the gas in the syringe to identify its functional group.

Include the expected result.

(2)

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(c) Calculate the percentage of 1-bromobutane which was converted to but-1-ene.

[Molar volume of a gas at r.t.p. = 24 000 $cm^3 mol^{-1}$]

(2)

(d) Before cooling, the volume of but-1-ene in the gas syringe was 24.0 cm^3.

Calculate the temperature of the gas in the syringe before it cooled.

[Assume no loss from the gas syringe during cooling, and a constant pressure]

(2)

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(e) (i) Another compound formed from 1-bromobutane under these conditions is butan-1-ol.

Identify the type of reaction taking place to form butan-1-ol.

(1)

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(ii) The functional group in butan-1-ol can be confirmed using a single chemical test.

What is the single chemical test and expected observation?

(1)

		Chemical test reagent	Observation
☒	**A**	sodium carbonate solution	effervescence
☒	**B**	aqueous silver nitrate	cream precipitate
☒	**C**	Fehling's solution	red precipitate
☒	**D**	phosphorus(V) chloride	steamy fumes

(iii) Draw the mechanism for the reaction of 1-bromobutane with hydroxide ions to form butan-1-ol.

Include curly arrows, and any appropriate lone pairs and dipoles.

(3)

(f) Alkene molecules are formed by elimination from 2-bromobutane.

How many isomeric alkene products will be formed in this reaction?

(1)

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 5 = 13 marks)

6 Wine and gin are aqueous solutions of ethanol with traces of other organic compounds which give these drinks their characteristic flavours and aromas.

(a) When a bottle of wine is opened, oxidation of the ethanol in the wine produces ethanoic acid.

An experiment was carried out to determine the percentage of the ethanol that had been oxidised.

- A bottle of white wine, with an ethanol concentration of 2.50 mol dm^{-3}, was opened and left to stand at room temperature for three weeks.
- A 25.0 cm^3 sample of the wine was transferred to a conical flask and phenolphthalein indicator added.
- Aqueous sodium hydroxide of concentration 0.235 mol dm^{-3} was added from a burette until the colour of the indicator permanently changed.
- The titration was repeated and the titre values, in cm^3, were 27.90, 26.75 and 26.85.

The equation for the neutralisation reaction is

$$CH_3COOH + NaOH \rightarrow CH_3COO^-Na^+ + H_2O$$

(i) Name the piece of apparatus used to measure 25.0 cm^3 of wine.

(1)

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(ii) To improve the accuracy, the burette should be rinsed.

State what should be used.

(1)

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(iii) What is the colour change at the end-point?

(1)

☒ **A** from orange to yellow

☒ **B** from red to orange

☒ **C** from colourless to pink

☒ **D** from pink to colourless

(iv) State what is meant by the term 'concordant results' as applied to a titration experiment.

(1)

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(v) Calculate the percentage of ethanol that has oxidised, given that one mole of ethanol forms one mole of ethanoic acid.

Give your answer to an appropriate number of significant figures.

(5)

(vi) Deduce why this method would **not** be effective for the analysis of the acid content of a red wine.

(1)

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(b) The ethanol content of alcoholic drinks is usually measured as the percentage of alcohol by volume (ABV).

$$\text{ABV} = \frac{\text{Volume of ethanol in a solution}}{\text{Total volume of the solution}} \times 100$$

The ABV values of four different brands of gin are shown.

Brand of gin	ABV (%)
A	40
B	42
C	44
D	46

A sample of one of these gins was found to contain an ethanol concentration of 7.50 mol dm^{-3}.

By calculating the percentage of ethanol by volume (ABV) of this sample, deduce the brand of this gin.

[Assume the density of ethanol, C_2H_5OH = 0.79 g cm^{-3}]

(3)

(Total for Question 6 = 13 marks)

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7 This question is about compounds with the molecular formula C_4H_8O.

(a) What is the percentage by mass of each element in C_4H_8O?

(1)

	Percentage carbon	Percentage hydrogen	Percentage oxygen
☒ **A**	66.67	11.11	22.22
☒ **B**	60.00	20.00	20.00
☒ **C**	41.38	3.45	55.17
☒ **D**	30.77	61.54	7.69

*(b) Three different compounds, **A**, **B** and **C**, have the molecular formula C_4H_8O.

Information about these three compounds includes:

- all three compounds have infrared absorptions at about 3500 cm^{-1}
- the infrared spectra of **A** and **B** each contain a peak at about 1650 cm^{-1}, while that of **C** does not
- only **A** has a branched carbon chain
- **B** is the *E*-isomer of a pair of stereoisomers.

Deduce a possible **displayed** formula for each of the compounds **A**, **B** and **C**.

You must use **all** the information and the Data Booklet to fully justify each of your structures.

(6)

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(Total for Question 7 = 7 marks)

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8 Compound **X** reacts slowly with water according to the following equation.

$$\mathbf{X}(s) + H_2O(l) \rightarrow \mathbf{Y}(aq) + Z^-(aq) + H^+(aq)$$

The reaction is catalysed by hydrogen ions and eventually goes to completion.

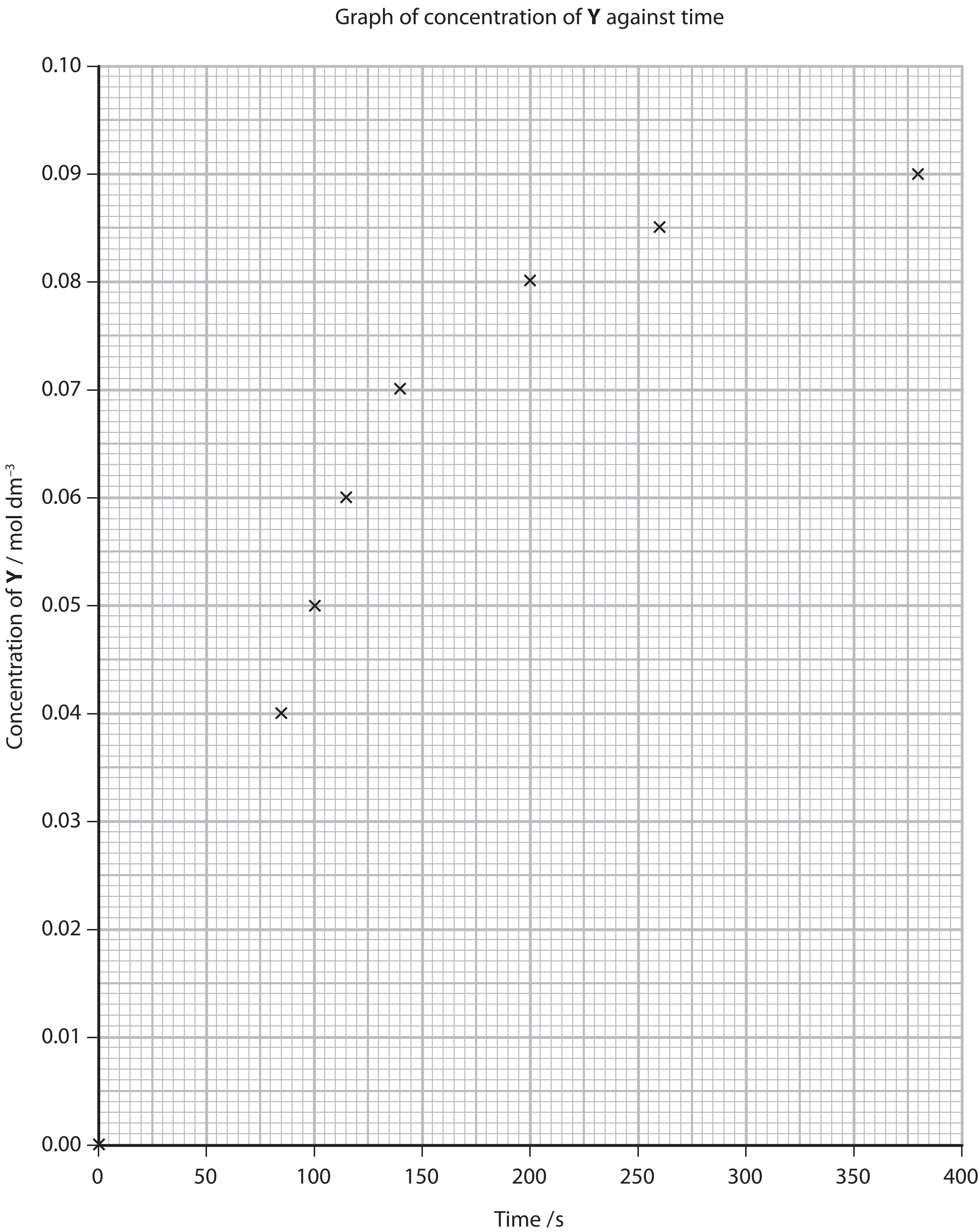
Compound **X** was added to water and the concentration of compound **Y** determined at various times at a constant temperature.

The results of the experiment are shown.

Time / s	Concentration of **Y** / mol dm^{-3}
0	0.000
25	0.002
40	0.005
50	0.010
65	0.020
75	0.030
85	0.040
100	0.050
115	0.060
140	0.070
200	0.080
260	0.085
380	0.090

(a) (i) Complete the graph of concentration against time by adding the six missing points. Draw a line to pass through **all** the points.

(2)



Graph of concentration of **Y** against time
Concentration of **Y** / mol dm^{-3}
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
50
100
150
200
250
300
350
400
Time /s

(ii) Describe how you would find a numerical value for the initial rate of reaction and for the maximum rate of reaction in this experiment from the graph. No actual calculations are required.

(4)

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(b) For many reactions, the values of the initial rate and the maximum rate are the same.

Explain why the values of the two reaction rates obtained in this experiment are different from each other.

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(c) Give a reason why the measurement of the initial rate of reaction is likely to be less accurate than the measurement of the maximum rate.

(1)

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(Total for Question 8 = 9 marks)

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0 (8)
							1.0 **H** hydrogen 1										*(18)*
																	4.0 **He** helium 2
(1)	*(2)*											*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	
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	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(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

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
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

* Lanthanide series
* Actinide series