Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

Paper reference **WCH12/01**

Chemistry

International Advanced Subsidiary/Advanced Level
UNIT 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

You must have:
Scientific calculator, Data Booklet, ruler

Total Marks

Instructions

- Use **black** ink or 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.*
- In the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how 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.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P70965A

Q:1/1/1/

P 7 0 9 6 5 A 0 1 2 8

Pearson

SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which equation represents the standard enthalpy change of formation, $\Delta_f H^{\ominus}$, for aluminium oxide?

☒ **A** $2Al(s) + 1½O_2(g) \rightarrow Al_2O_3(s)$

☒ **B** $2Al(s) + 3O(g) \rightarrow Al_2O_3(s)$

☒ **C** $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

☒ **D** $4Al(s) + 6O(g) \rightarrow 2Al_2O_3(s)$

(Total for Question 1 = 1 mark)

2 How does an oxidising agent change during a redox reaction?

	Electrons	Oxidation number
☒ **A**	gains electrons	decreases
☒ **B**	gains electrons	increases
☒ **C**	loses electrons	decreases
☒ **D**	loses electrons	increases

(Total for Question 2 = 1 mark)

3 Which of these compounds would be expected to have the **highest** boiling temperature?

☒ **A** $(CH_3)_3COH$

☒ **B** $CH_3CH_2CH_2CH_2OH$

☒ **C** $CH_3CH_2CH(CH_3)_2$

☒ **D** $CH_3CH_2CH_2CH_2CH_3$

(Total for Question 3 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

4 What is the name of the compound with the formula $KClO_2$?

- ☒ **A** potassium chlorate(II)
- ☒ **B** potassium chlorate(III)
- ☒ **C** potassium chlorate(IV)
- ☒ **D** potassium chlorate(V)

(Total for Question 4 = 1 mark)

5 A small piece of calcium is added to a beaker of distilled water.

(a) Which is the equation for this reaction?

(1)

- ☒ **A** $Ca + H_2O \rightarrow CaO + H_2$
- ☒ **B** $Ca + 2H_2O \rightarrow CaO_2 + 2H_2$
- ☒ **C** $Ca + H_2O \rightarrow CaOH + \frac{1}{2}H_2$
- ☒ **D** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

(b) Which element is oxidised and which is reduced when calcium reacts with water?

(1)

		Element oxidised	Element reduced
☒	**A**	calcium	hydrogen
☒	**B**	calcium	oxygen
☒	**C**	hydrogen	calcium
☒	**D**	hydrogen	oxygen

(Total for Question 5 = 2 marks)

6 Which is the ionic equation for the reaction of solid barium carbonate with dilute hydrochloric acid?

- ☒ **A** $BaCO_3(s) + 2H^+(aq) \rightarrow Ba^{2+}(aq) + CO_2(g) + H_2O(l)$
- ☒ **B** $Ba_2CO_3(s) + 2H^+(aq) \rightarrow 2Ba^+(aq) + CO_2(g) + H_2O(l)$
- ☒ **C** $CO_3^{2-}(s) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$
- ☒ **D** $CO_3^{2-}(s) + 2HCl(aq) \rightarrow 2Cl^-(aq) + CO_2(g) + H_2O(l)$

(Total for Question 6 = 1 mark)

7 The presence of ammonium ions in a compound can be shown by adding a reagent, warming the mixture and testing the gas evolved.

What is the reagent and the result of the test for the gas evolved?

	Reagent	Result of test for gas
☒ **A**	HCl(aq)	damp blue litmus paper turns red
☒ **B**	HCl(aq)	damp red litmus paper turns blue
☒ **C**	NaOH(aq)	damp blue litmus paper turns red
☒ **D**	NaOH(aq)	damp red litmus paper turns blue

(Total for Question 7 = 1 mark)

8 Aqueous chlorine is added to an aqueous solution of potassium iodide.
A non-polar organic solvent is then added and the mixture is shaken.
The layers are allowed to separate.

What colour is seen in the organic layer?

☒ **A** brown

☒ **B** green

☒ **C** orange

☒ **D** violet

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 A titration is carried out by adding dilute sulfuric acid from a burette to aqueous sodium hydroxide in a conical flask. The indicator is methyl orange.

(a) What is the colour change of the indicator at the end-point of this titration?

(1)

- ☒ **A** red to orange
- ☒ **B** red to yellow
- ☒ **C** yellow to orange
- ☒ **D** yellow to red

(b) A student carried out the first titration and did not notice that there was an air bubble between the tap and the tip of the burette.
During the titration, the air bubble filled with acid.

The student then carried out two accurate titrations in which there was no air bubble in the burette. There were no other errors in these titrations.

Which of these could be the three titres for this student?

(1)

	First titre / cm^3	Second titre / cm^3	Third titre / cm^3
☒ **A**	22.65	22.65	22.65
☒ **B**	22.65	22.35	23.25
☒ **C**	22.80	22.35	22.40
☒ **D**	22.80	23.25	23.30

(c) 25.0 cm^3 of 0.100 mol dm^{-3} aqueous sodium hydroxide required a mean titre of 18.70 cm^3 of sulfuric acid.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

What is the concentration, in mol dm^{-3}, of the sulfuric acid?

(1)

- ☒ **A** 0.0374
- ☒ **B** 0.0668
- ☒ **C** 0.134
- ☒ **D** 0.267

(Total for Question 9 = 3 marks)

10 Hydrogen peroxide decomposes as shown.

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

(a) A catalyst increases the rate of decomposition by

(1)

- ☒ **A** increasing the average kinetic energy of the H_2O_2 molecules
- ☒ **B** decreasing the average kinetic energy of the H_2O_2 molecules
- ☒ **C** increasing the activation energy of the reaction
- ☒ **D** decreasing the activation energy of the reaction

(b) A bottle of hydrogen peroxide is labelled as '10 volume'.

This means that 1 cm^3 of hydrogen peroxide solution decomposes to produce 10 cm^3 oxygen at room temperature and pressure (r.t.p.).

What is the concentration of 10 volume hydrogen peroxide, in mol dm^{-3}?

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

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

(1)

- ☒ **A** 0.100
- ☒ **B** 0.208
- ☒ **C** 0.417
- ☒ **D** 0.833

(Total for Question 10 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

11 A mixture of hydrogen and iodine is left in a sealed container at 300 °C until equilibrium is established.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

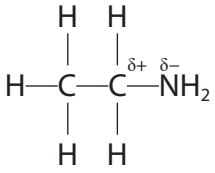
The equilibrium mixture is then cooled and the colour of the mixture darkens.

Which is correct?

		Change in position of equilibrium when the system is cooled	Enthalpy change of forward reaction
☒	**A**	left	endothermic
☒	**B**	left	exothermic
☒	**C**	right	endothermic
☒	**D**	right	exothermic

(Total for Question 11 = 1 mark)

12 The structure of ethylamine is shown.



What type of reagent will attack the $C^{\delta+}$ atom?

☒ **A** electrophile

☒ **B** free radical

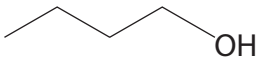
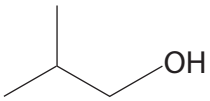
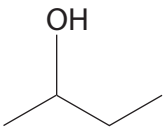
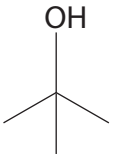
☒ **C** nucleophile

☒ **D** oxidising agent

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 Which of these alcohols will produce a carboxylic acid when heated under reflux with acidified potassium dichromate(VI)?

P 	**Q** 
R 	**S** 

☒ **A** **P** only

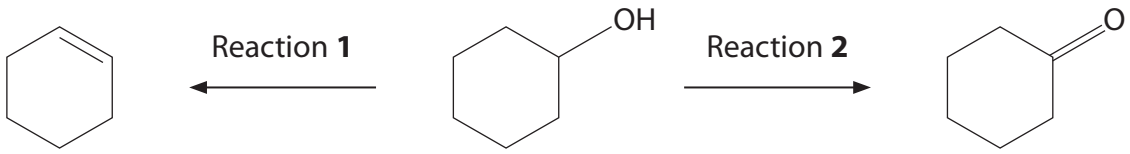
☒ **B** **P** and **Q** only

☒ **C** **P**, **Q** and **R** only

☒ **D** **P**, **Q**, **R** and **S**

(Total for Question 13 = 1 mark)

14 Two reactions of cyclohexanol are shown.



cyclohexene cyclohexanol cyclohexanone

(a) What is the reagent for Reaction **1**?

(1)

☒ **A** acidified potassium manganate(VII)

☒ **B** aqueous bromine

☒ **C** concentrated phosphoric(V) acid

☒ **D** phosphorus(V) chloride

(b) The reagent for Reaction **2** is acidified potassium dichromate(VI).

Which equation best represents this reaction?

(1)

☒ **A** $C_6H_{11}OH \rightarrow C_6H_{10}O + H_2$

☒ **B** $C_6H_{11}OH \rightarrow C_6H_{10}O + 2[H]$

☒ **C** $C_6H_{11}OH + [O] \rightarrow C_6H_{10}O + H_2O$

☒ **D** $C_6H_{11}OH + ½O_2 \rightarrow C_6H_{10}O + H_2O$

(c) Cyclohexanol and cyclohexene each has a peak in their infrared spectrum which is **not** present for the other compound.

Which are these peaks?

(1)

		Peak only in cyclohexanol / cm^{-1}	Peak only in cyclohexene / cm^{-1}
☒	**A**	2962-2853	1669-1645
☒	**B**	2962-2953	1720-1700
☒	**C**	3750-3200	1669-1645
☒	**D**	3750-3200	1720-1700

(Total for Question 14 = 3 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

15 This question is about calcium carbonate, $CaCO_3$.

(a) Calcium carbonate decomposes on heating.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Explain why calcium carbonate decomposes at a higher temperature than magnesium carbonate, in terms of the charge and size of the cations.

(3)

(b) Calcium carbonate reacts with dilute hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

A student determines the initial rate of this reaction by collecting the carbon dioxide in a gas syringe and measuring the volume at regular time intervals.

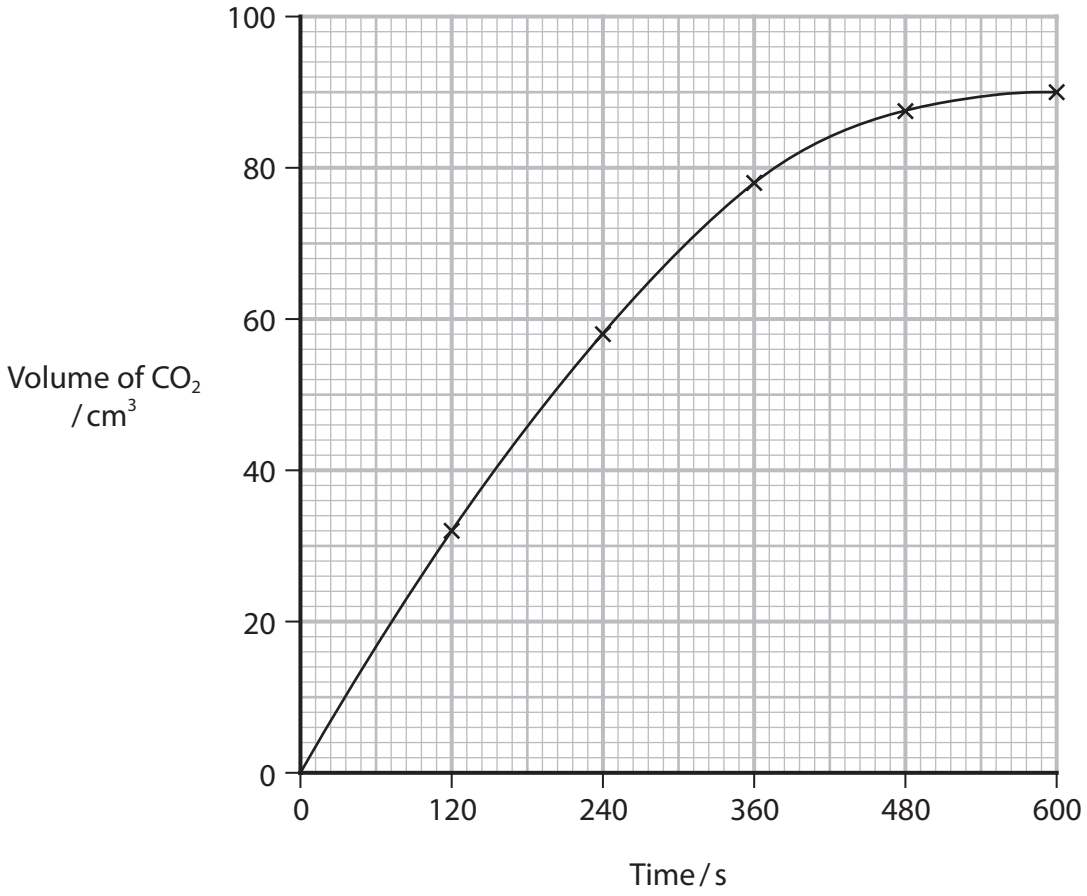
(i) The gas syringe can measure a maximum of 100 cm^3 of gas.

Calculate the **maximum** volume of 0.500 mol dm^{-3} hydrochloric acid that can be added to excess calcium carbonate at room temperature and pressure (r.t.p.) without exceeding the measurable volume of the gas syringe.

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

(3)

(ii) The results of the student's experiment are shown on the graph.



Calculate the initial rate of this reaction.
You **must** show your working on the graph.
Include units in your answer.

(3)

(iii) The student repeats the experiment but uses hydrochloric acid with a concentration of 0.250 mol dm^{-3}. All other variables are kept the same.

State what would happen to the initial rate of reaction and the final volume of carbon dioxide collected.

(1)

Initial rate of reaction

.....

Final volume of carbon dioxide collected

.....

(Total for Question 15 = 10 marks)

BLANK PAGE

16 This question is about the halogens and some of their compounds.

(a) Descending the group from fluorine to iodine, the electronegativity of the atoms decreases even though their nuclear charge increases.

Explain the trend in electronegativity.

(2)

(b) Iodate(V) ions, IO_3^-, react with iodide ions in acid solution.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$$

Explain, in terms of the oxidation numbers of iodine in the three species, why this is **not** a disproportionation reaction.

(2)

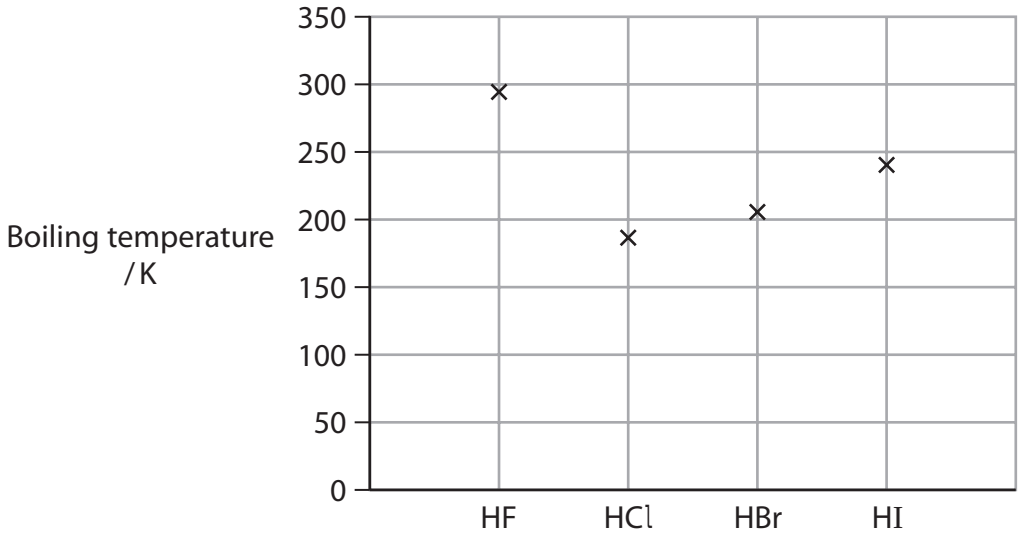
(c) Hydrogen bromide and hydrogen iodide reduce sulfuric acid.

Identify, by name or formula, the **compound** produced containing sulfur with its lowest oxidation number in that reaction.

(1)

Hydrogen halide	Compound produced with the lowest oxidation number of sulfur
HBr	
HI	

(d) The graph shows the boiling temperatures of the hydrogen halides.



Explain the trend in the boiling temperatures of the hydrogen halides.

(4)

(e) A sample of seawater was evaporated to dryness.

The solid residue was weighed, then dissolved completely in deionised water.

Excess aqueous silver nitrate was added to the solution.
All the chloride ions in the seawater formed a precipitate of silver chloride.

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

The precipitate was filtered, washed, dried and weighed.

Results:

Mass of solid residue from seawater = 0.098 g

Mass of silver chloride precipitate = 0.226 g

Calculate the percentage, by mass, of chloride ions in the solid residue.

[Assume silver chloride is the only precipitate.]

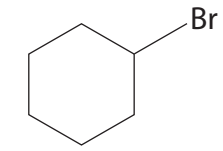
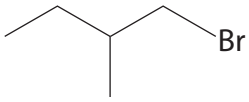
(3)

(Total for Question 16 = 12 marks)

17 This question is about some halogenoalkanes.

(a) Give the classification of each halogenoalkane shown in the table as primary, secondary or tertiary.

(1)

Halogenoalkane	Classification
	
	

(b) Samples of 1-iodobutane and 2-chloro-2-methylpropane were hydrolysed using aqueous silver nitrate in ethanol.

Explain whether or not it is possible to predict the relative rate of hydrolysis of these two compounds.

(3)

(c) Butylamine is formed when 1-bromobutane reacts with excess concentrated alcoholic ammonia.

$$CH_3CH_2CH_2CH_2Br + 2NH_3 \rightarrow CH_3CH_2CH_2CH_2NH_2 + NH_4Br$$

(i) Give a reason why this reaction should be carried out by heating the reactants in a sealed tube rather than heating under reflux.

(1)

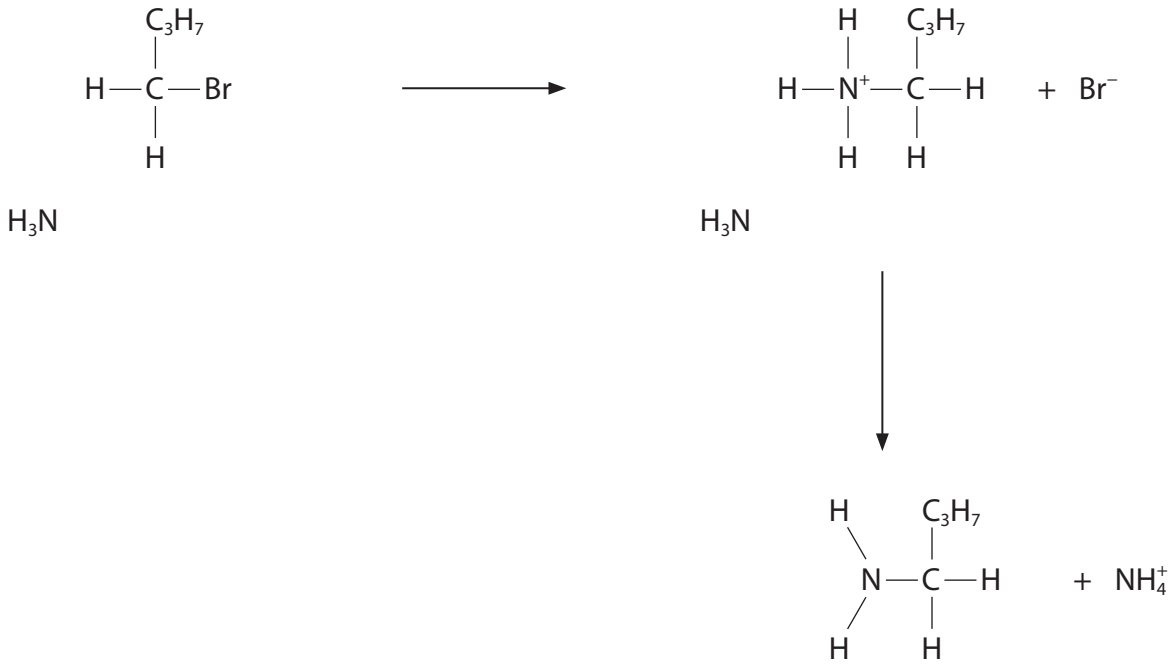
.....

.....

.....

(ii) Complete the mechanism for this reaction by adding curly arrows, and any relevant lone pairs and dipoles.

(4)



(d) Bromoethane is prepared by reacting ethanol with potassium bromide and concentrated sulfuric acid.

$$C_2H_5OH + KBr + H_2SO_4 \rightarrow C_2H_5Br + KHSO_4 + H_2O$$

Calculate the maximum mass of bromoethane that could be prepared from 4.65 g of ethanol, 14.90 g of potassium bromide and a solution containing 16.35 g of H_2SO_4.

[A_r values: H = 1.0 C = 12.0 O = 16.0 S = 32.1 K = 39.1 Br = 79.9]

(3)

*(e) The reaction between 2-bromopropane and potassium hydroxide takes place under two different conditions:

- in aqueous solution
- in ethanolic solution.

Compare and contrast these two reactions.

Include equations for the reactions.
Detailed mechanisms of these reactions are **not** required.

(6)

(Total for Question 17 = 18 marks)

TOTAL FOR SECTION B = 40 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

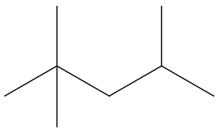
18

Fuels

Fuels burn in oxygen to release a lot of energy.

Many hydrocarbons and alcohols are used as fuels. During complete combustion, they produce carbon dioxide and water.

Petrol contains 2,2,4-trimethylpentane, an isomer of octane, that promotes smooth combustion.



2,2,4-trimethylpentane

Alcohols, such as methanol and ethanol, can be used as fuels either on their own or as additives in petrol.

(a) The standard enthalpy change of combustion, $\Delta_c H^{\ominus}$, of 2,2,4-trimethylpentane is $-5461\ kJ\ mol^{-1}$.

(i) State the two standard conditions for this enthalpy change.

(1)

.....

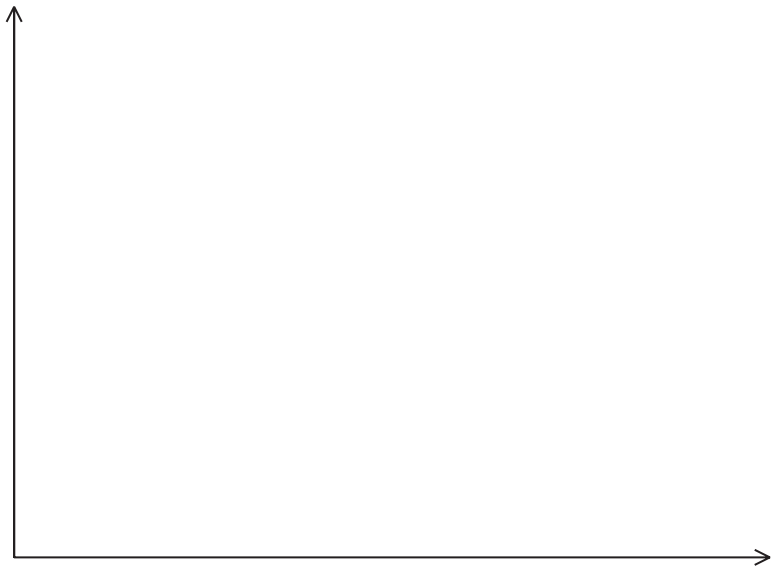
.....

(ii) Write the equation for the complete combustion of 2,2,4-trimethylpentane, using **molecular** formulae.
State symbols are not required.

(2)

(iii) Draw a labelled enthalpy level diagram for the complete combustion of 2,2,4-trimethylpentane.

(2)

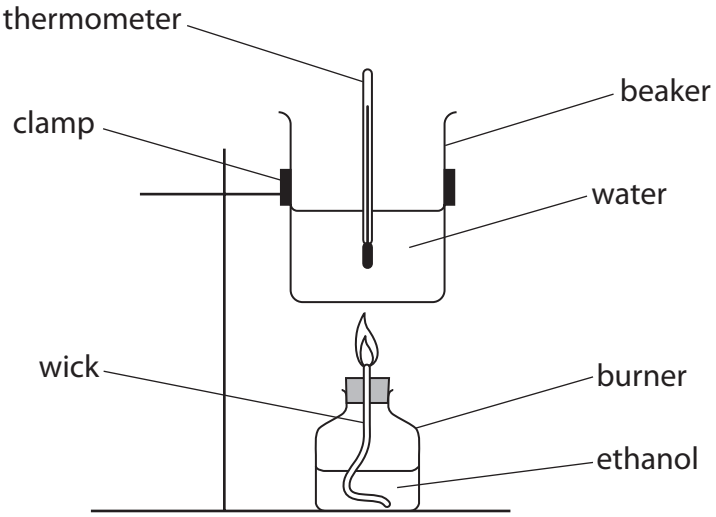


(iv) Calculate the heat energy released during the complete combustion of 1 dm^3 of 2,2,4-trimethylpentane.

[Density of 2,2,4-trimethylpentane = 0.692 g cm^{-3}]

(3)

(b) In an experiment to determine the enthalpy change of combustion of ethanol, C_2H_5OH, a student used the apparatus shown.



Results:

Mass of water = 100.0 g

Mass of ethanol used = 0.305 g

Temperature rise of water = 13.2 °C

(i) Calculate the enthalpy change of combustion of ethanol.

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

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

(4)

(ii) The uncertainty in each thermometer reading is ±0.05 °C.

Calculate the percentage uncertainty in the temperature rise in this experiment.

(1)

(iii) The student looked in a data book and found the actual value for the standard enthalpy change of combustion of ethanol was more exothermic than the experimental value obtained.

Give **two** reasons for the difference between the data book value and the experimental value, other than referring to standard conditions.

(2)

(c) The enthalpy changes for the conversion of four compounds in the gas phase into their constituent atoms are shown.

$H_2O(g) \rightarrow 2H(g) + O(g)$ $\Delta_r H = +928\,kJ\,mol^{-1}$

$CH_4(g) \rightarrow C(g) + 4H(g)$ $\Delta_r H = +1740\,kJ\,mol^{-1}$

$CH_3OH(g) \rightarrow C(g) + 4H(g) + O(g)$ $\Delta_r H = +2105\,kJ\,mol^{-1}$

$C_2H_5OH(g) \rightarrow 2C(g) + 6H(g) + O(g)$ $\Delta_r H = +3322\,kJ\,mol^{-1}$

Calculate the bond enthalpy of the C—C bond, in $kJ\,mol^{-1}$.
You **must** show your working.

(3)

(d) Ethanol can be manufactured by reacting ethene with steam.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta_r H = -45\,kJ\,mol^{-1}$$

This reaction is usually carried out in industry at 300 °C and 70 atm pressure using a catalyst.

Explain the effect on the equilibrium position and the equilibrium yield of ethanol if the reaction is carried out at 300 °C and 200 atm pressure.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 18 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										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							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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