

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				
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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 **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.*
- 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.
- Check your answers if you have time at the end.

Turn over ►

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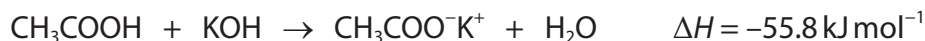
SECTION A

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 . If you change your mind, put a line through the box and then mark your new answer with a cross .

- 1 Which are correct for the reaction shown?



	Type of reaction	Type of enthalpy change
<input type="checkbox"/> A	endothermic	formation
<input type="checkbox"/> B	endothermic	neutralisation
<input type="checkbox"/> C	exothermic	formation
<input type="checkbox"/> D	exothermic	neutralisation

(Total for Question 1 = 1 mark)

- 2 Which equation does **not** represent a standard enthalpy change of atomisation?

- A $\text{Mg(s)} \rightarrow \text{Mg(g)}$
- B $\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl(g)}$
- C $\frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{O(g)}$
- D $\text{Hg(l)} \rightarrow \text{Hg(g)}$

(Total for Question 2 = 1 mark)

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



3 5.20 g of sodium hydrogencarbonate is added to an excess of acid.

The temperature increases and the energy change is calculated to be 1030 J.

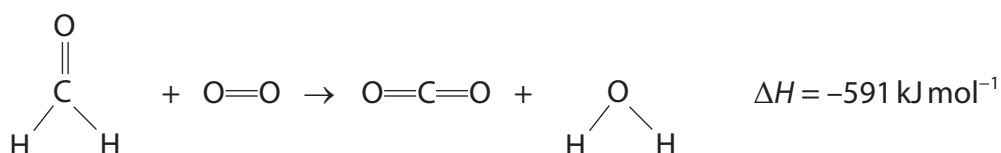
What is the enthalpy change per mole of sodium hydrogencarbonate?

[$M_r \text{ NaHCO}_3 = 84.0$]

- A $-12.3 \text{ kJ mol}^{-1}$
- B $-16.6 \text{ kJ mol}^{-1}$
- C $-63.8 \text{ kJ mol}^{-1}$
- D $-16\,600 \text{ kJ mol}^{-1}$

(Total for Question 3 = 1 mark)

4 The equation for the complete combustion of methanal is shown.



Some bond enthalpy data are shown.

Bond	Bond enthalpy / kJ mol^{-1}
C—H	413
O=O	498
C=O in CO_2	805
O—H	464

What is the C=O bond enthalpy in methanal?

- A 623 kJ mol^{-1}
- B 678 kJ mol^{-1}
- C 805 kJ mol^{-1}
- D 1036 kJ mol^{-1}

(Total for Question 4 = 1 mark)



5 Which sequence shows the molecules in order of **increasing** boiling temperature?

- A $\text{H}_2\text{O} < \text{Br}_2 < \text{Cl}_2 < \text{CH}_4$
- B $\text{Br}_2 < \text{CH}_4 < \text{Cl}_2 < \text{H}_2\text{O}$
- C $\text{Cl}_2 < \text{CH}_4 < \text{H}_2\text{O} < \text{Br}_2$
- D $\text{CH}_4 < \text{Cl}_2 < \text{Br}_2 < \text{H}_2\text{O}$

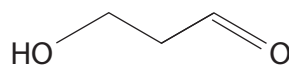
(Total for Question 5 = 1 mark)

6 Which is **not** correct about ice?

- A ice has a lower density than water
- B H_2O molecules are further apart in ice than in water
- C the H–O–H bond angle is the same in ice and in water
- D H_2O molecules in ice are held together by hydrogen bonds

(Total for Question 6 = 1 mark)

7 Which intermolecular forces exist **between** the molecules of the compound shown?



- A hydrogen bonding and London forces only
- B hydrogen bonding and permanent dipole-permanent dipole forces only
- C London forces and permanent dipole-permanent dipole forces only
- D hydrogen bonding, permanent dipole-permanent dipole forces and London forces

(Total for Question 7 = 1 mark)

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8 This question is about alkanes.

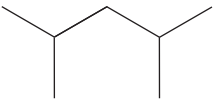
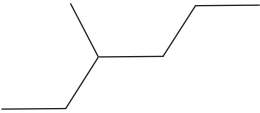
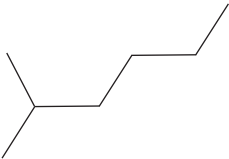
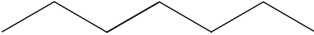
(a) Which of these alkanes has the **highest** boiling temperature?

(1)

- A butane
- B hexane
- C pentane
- D propane

(b) Which of these alkanes has the **lowest** boiling temperature?

(1)

- A 
- B 
- C 
- D 

(Total for Question 8 = 2 marks)

9 Which solvent dissolves the greatest amount of hydrocarbon $C_{35}H_{72}$?

- A butan-1-ol
- B ethanoic acid
- C hexane
- D water

(Total for Question 9 = 1 mark)

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



P 6 9 5 0 1 A 0 5 2 8

10 Which reagent would convert an alcohol into an alkene?

- A acidified potassium dichromate(VI)
- B anhydrous calcium sulfate
- C concentrated phosphoric acid
- D ethanolic potassium hydroxide

(Total for Question 10 = 1 mark)

11 Which name is correct for the ion SO_4^{2-} ?

- A sulfate(II)
- B sulfate(IV)
- C sulfate(VI)
- D sulfate(VIII)

(Total for Question 11 = 1 mark)

12 In which compound is the oxidation number of nitrogen +5?

- A $\text{Ca}(\text{NO}_3)_2$
- B Mg_3N_2
- C N_2O_3
- D NaNO_2

(Total for Question 12 = 1 mark)

13 In which reaction is the copper species acting as an oxidising agent?

- A $\text{Cu}^{2+} + 2\text{Ag} \rightarrow 2\text{Ag}^+ + \text{Cu}$
- B $2\text{Cu}^+ + \text{O}^{2-} \rightarrow \text{Cu}_2\text{O}$
- C $3\text{Cu} + \text{O}_2 \rightarrow \text{Cu}_2\text{O} + \text{CuO}$
- D $\text{Cu} + \text{Hg}^{2+} \rightarrow \text{Hg} + \text{Cu}^{2+}$

(Total for Question 13 = 1 mark)

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



14 Two half-equations for a reaction are shown.



What is the overall ionic equation for this reaction?

- A $\text{Cu} + \text{NO}_3^{-} + 4\text{H}^{+} \rightarrow \text{Cu}^{2+} + \text{NO} + 2\text{H}_2\text{O}$
- B $2\text{Cu} + \text{NO}_3^{-} + 4\text{H}^{+} \rightarrow 2\text{Cu}^{2+} + \text{NO} + 2\text{H}_2\text{O}$
- C $3\text{Cu} + 2\text{NO}_3^{-} + 8\text{H}^{+} \rightarrow 3\text{Cu}^{2+} + 2\text{NO} + 4\text{H}_2\text{O}$
- D $6\text{Cu} + 2\text{NO}_3^{-} + 8\text{H}^{+} \rightarrow 6\text{Cu}^{2+} + 2\text{NO} + 4\text{H}_2\text{O}$

(Total for Question 14 = 1 mark)

15 A titre of 13.25 cm^3 was obtained using a 50 cm^3 burette.

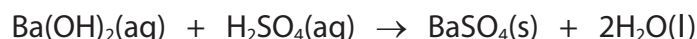
What is the percentage uncertainty in the titre?

[Each reading of the burette has an uncertainty of $\pm 0.05 \text{ cm}^3$]

- A $\pm 0.38 \%$
- B $\pm 0.75 \%$
- C $\pm 1.5 \%$
- D $\pm 7.5 \%$

(Total for Question 15 = 1 mark)

16 Barium hydroxide reacts with sulfuric acid as shown.



Which is the ionic equation for this reaction?

- A $\text{Ba}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) + 2\text{H}^{+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$
- B $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$
- C $\text{OH}^{-}(\text{aq}) + \text{H}^{+}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- D $\text{Ba}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) + 2\text{H}^{+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{Ba}^{2+}(\text{s}) + \text{SO}_4^{2-}(\text{s}) + 2\text{H}_2\text{O}(\text{l})$

(Total for Question 16 = 1 mark)



17 Four tests used to identify ions are shown:

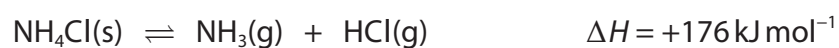
- 1 flame test
- 2 addition of acidified barium nitrate solution
- 3 addition of acidified silver nitrate solution
- 4 addition of sodium hydroxide solution, then testing any gas with indicator paper

Which tests could be used to positively identify the ions in ammonium chloride?

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

(Total for Question 17 = 1 mark)

18 Which conditions give the highest yield for the forward reaction?



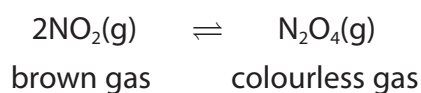
- A high temperature, high pressure
- B high temperature, low pressure
- C low temperature, high pressure
- D low temperature, low pressure

(Total for Question 18 = 1 mark)

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



19 Nitrogen dioxide and dinitrogen tetroxide exist in equilibrium.



When an equilibrium is set up in a gas syringe, the mixture is pale brown.

When the mixture is compressed the colour becomes

- A darker
- B lighter
- C darker and then lighter
- D lighter and then darker

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

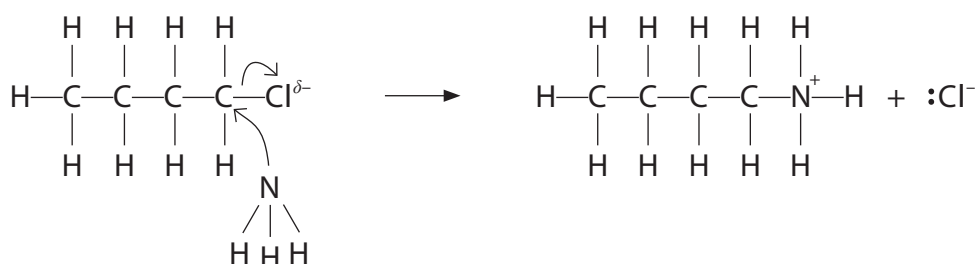
Answer ALL the questions. Write your answers in the spaces provided.

20 Ammonia reacts with 1-chlorobutane.

(a) State the type and mechanism of this reaction.

(2)

(b) A student drew the first step of the mechanism for the reaction.



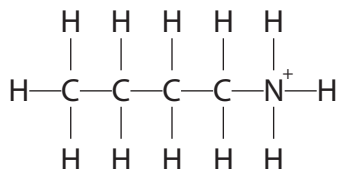
(i) Identify **two** omissions in the student's mechanism.

(2)

(ii) To obtain butylamine, sodium hydroxide solution is added.

Complete the next step of the mechanism to form butylamine, showing curly arrows, relevant lone pairs and the reaction products.

(3)



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(c) The reactions of ammonia and of hydroxide ions with halogenoalkanes are similar.

Compare the rate of reaction of ammonia with 1-chlorobutane and with 2-bromo-2-methylpropane.

Justify your answer.

(3)

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(Total for Question 20 = 10 marks)

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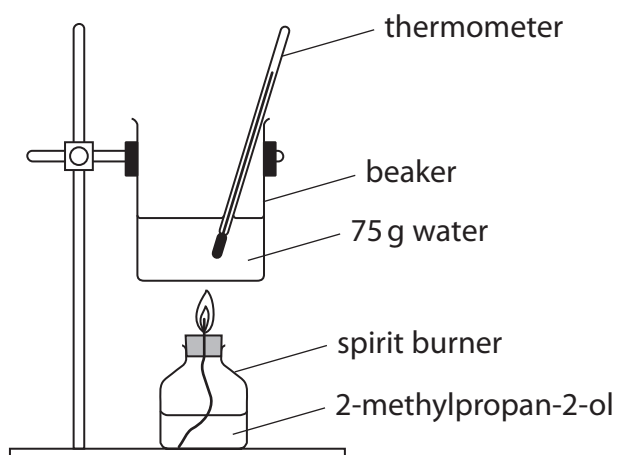
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21 Enthalpy changes of combustion can be determined using calorimetry or calculated using Hess cycles. Apparatus for a calorimetry experiment is shown.



A sample of 2-methylpropan-2-ol was burned in a spirit burner and used to heat 75 g of water. The results are shown.

	At the start	At the end	Change
Mass of spirit burner / g	267.35	266.78	
Temperature of water / °C	19.5	65.3	

(a) (i) Complete the table.

(1)

(ii) Calculate the enthalpy change of combustion, $\Delta_c H$, of 2-methylpropan-2-ol. Give a sign and units in your answer.

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

(4)

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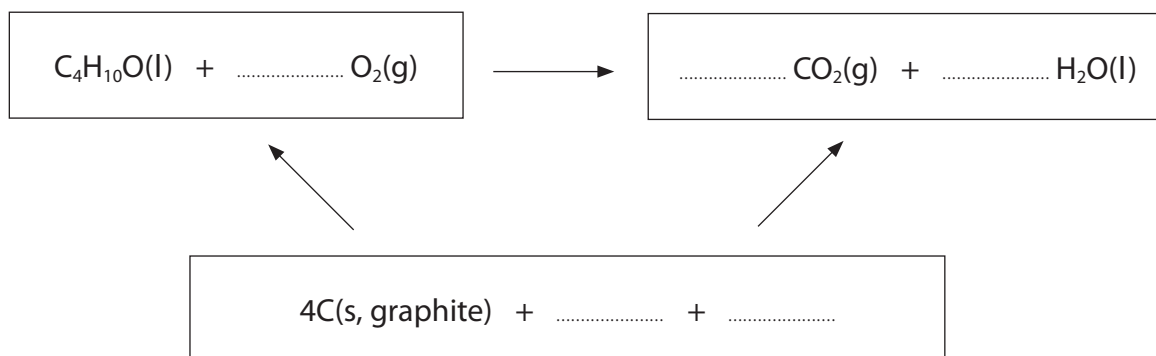
(b) The standard enthalpy change of combustion, $\Delta_c H^\ominus$, can be calculated using standard enthalpy changes of formation.

Compound	$\Delta_f H^\ominus / \text{kJ mol}^{-1}$
2-methylpropan-2-ol	-359
carbon dioxide	-394
water	-286

(i) State why no $\Delta_f H^\ominus$ value has been given for oxygen.

(1)

(ii) Complete the Hess cycle.



(2)

(iii) Calculate the standard enthalpy change of combustion of 2-methylpropan-2-ol using the data in the table and the completed Hess cycle.

(2)

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(c) The value for $\Delta_c H$ obtained in part (a)(ii) is much less exothermic than $\Delta_c H^\ominus$ calculated in (b)(iii).

Suggest **two** reasons for this other than non-standard conditions.

(2)

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(Total for Question 21 = 12 marks)



22 This question is about the elements in Group 7.

- (a) Use your knowledge of the trends in the properties of Group 7 elements to predict the colour and physical state of astatine at room temperature.

(1)

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- (b) (i) State the meaning of the term electronegativity.

(1)

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- (ii) Explain the trend in electronegativity down Group 7.

(2)

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*(c) Compare and contrast the reactions of chlorine with

- water
- cold, dilute aqueous alkali
- hot, concentrated aqueous alkali

Include an equation for each reaction, stating the type of reaction and the oxidation numbers of the chlorine involved. State symbols are not required.

(6)

Area with horizontal dotted lines for writing answers.



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Handwriting practice area with 20 horizontal dotted lines.

(Total for Question 22 = 10 marks)



23 Magnesium ethanedioate (MgC_2O_4) decomposes on gentle heating to form magnesium carbonate and carbon monoxide.



- (a) (i) State why the thermal decomposition of magnesium ethanedioate should be carried out in a fume cupboard.

(1)

- (ii) After heating a 6.0g sample of magnesium ethanedioate for three minutes, the decomposition was 70% complete.

Calculate the total mass of the solid mixture that remains.

(4)

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- (b) Magnesium carbonate undergoes thermal decomposition at a higher temperature than magnesium ethanedioate.



Explain the trend in the thermal decomposition of Group 2 carbonates going down the group.

(3)

(Total for Question 23 = 8 marks)

TOTAL FOR SECTION B = 40 MARKS

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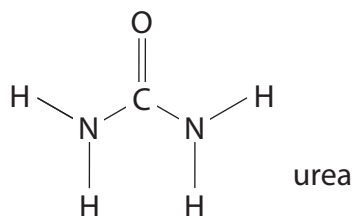


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SECTION C

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

- 24 Some diesel cars contain an extra catalytic converter for the reduction of nitrogen oxides (NO_x) in exhaust gases. A solution of urea is used for this process.



- (a) Urea has a melting temperature of 133°C .

Explain why this value is higher than expected for a relatively small molecule.

(3)

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- (b) A saturated solution of urea has a concentration of 9.07 mol dm^{-3} at 25°C .

Calculate the mass of urea in 150 cm^3 of a saturated solution.

(2)

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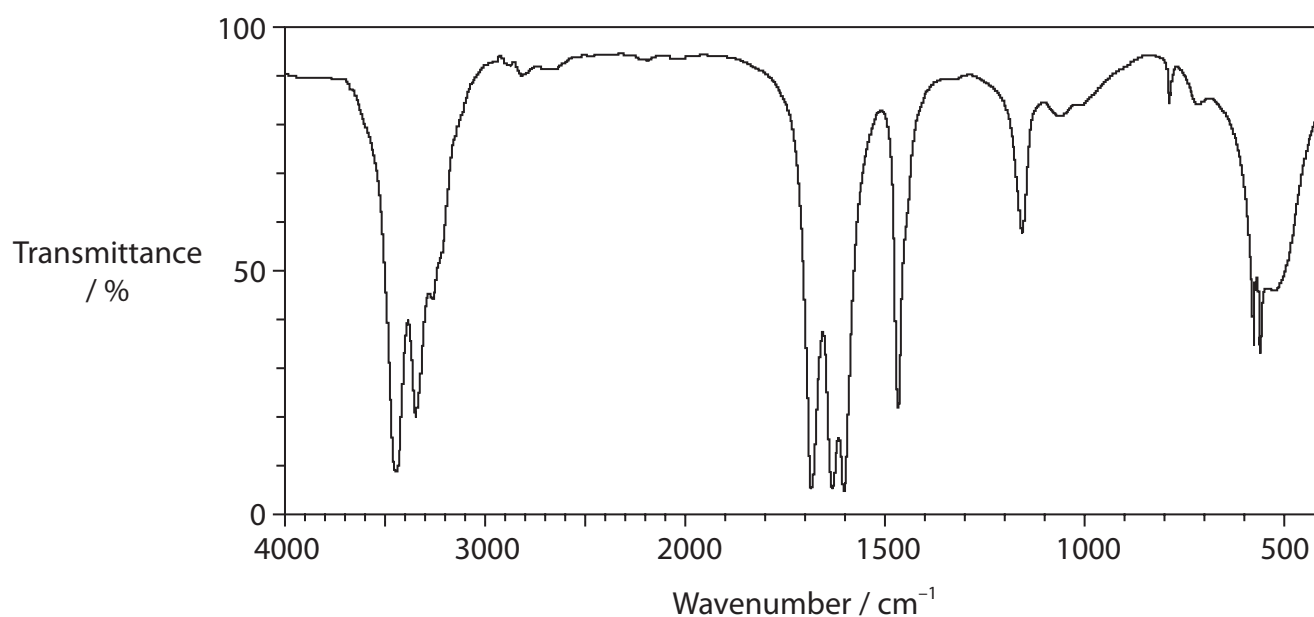
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(c) State why NO_x emissions are harmful to the environment.

(1)

(d) An infrared spectrum of urea is shown.
Refer to your Data Booklet.



(i) Draw a circle around an absorption in the spectrum that could be due to the stretching of the N—H bond.

(1)

(ii) Identify the bond responsible for the absorption at 1683 cm^{-1} .

(1)

(e) In a diesel car exhaust system, the urea reacts with water to form ammonia and carbon dioxide. The enthalpy change for this reaction is $+133\text{ kJ mol}^{-1}$.

(i) Complete the equation for this **reversible** reaction.

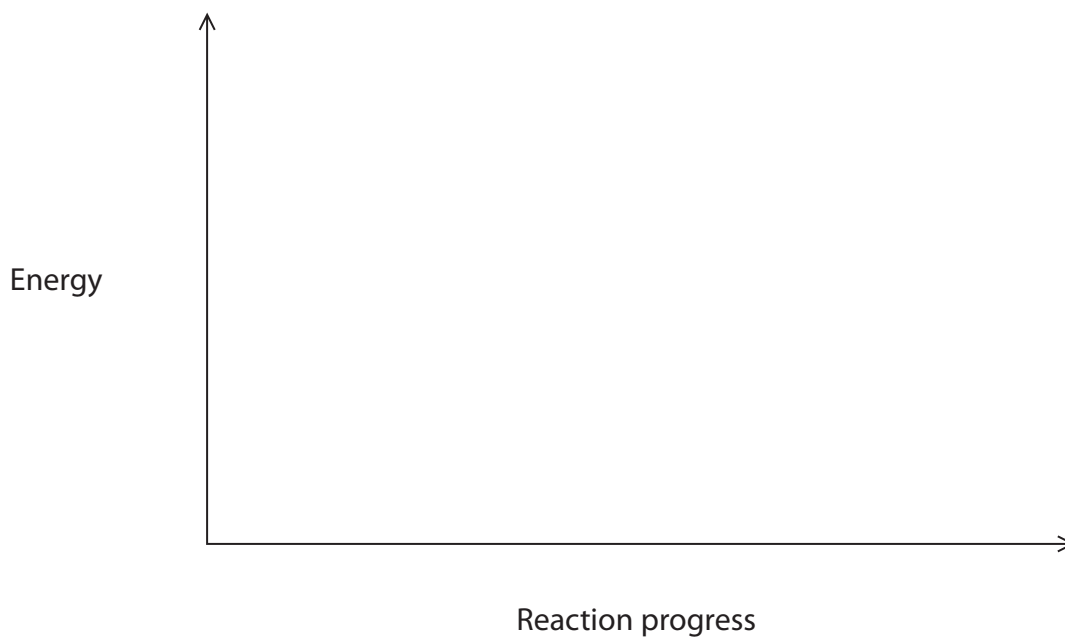
State symbols are not required.

(1)



(ii) Sketch the reaction profile for the forward reaction on the axes provided.

Include labels for ΔH and the activation energy (E_a).



(3)

(f) The catalytic converter contains metal oxides. When the exhaust gases pass through the catalytic converter, ammonia reacts with NO_x gases to form nitrogen and water.

(i) Explain why it is **not** correct to state that urea is acting as a catalyst in the reaction.

(1)

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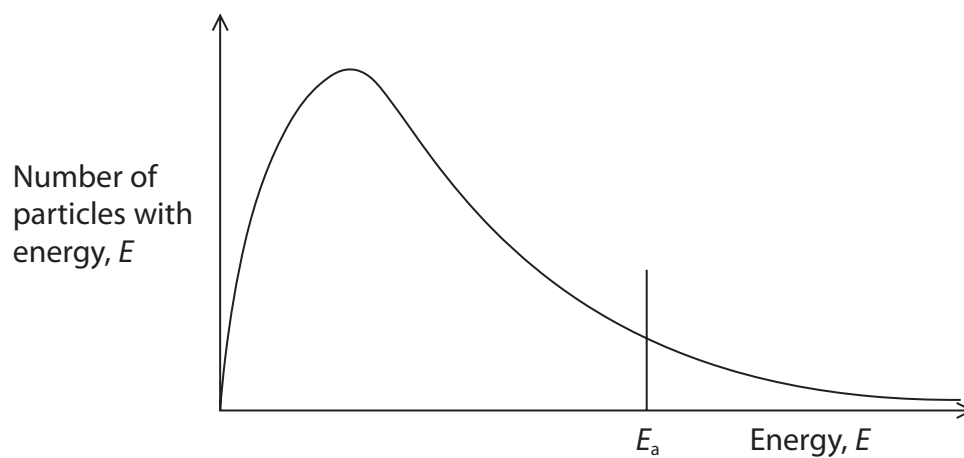
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(ii) Explain how a catalyst increases the rate of a chemical reaction.

Use the Maxwell-Boltzmann distribution shown and refer to the collision theory.

(3)



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(g) The catalytic converter works best at a temperature of around $350\text{ }^{\circ}\text{C}$.

(i) Suggest how the catalytic converter reaches this temperature.

(1)

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P 6 9 5 0 1 A 0 2 3 2 8

- (ii) The chemical reactions in the exhaust system of a diesel car, using a catalytic converter, form 89.3 m^3 of nitrogen per hour.

Calculate the number of molecules of nitrogen formed per hour.

[Molar volume at $350 \text{ }^\circ\text{C} = 51.1 \text{ dm}^3 \text{ mol}^{-1}$

Avogadro constant, $L = 6.02 \times 10^{23} \text{ mol}^{-1}$]

(3)

(Total for Question 24 = 20 marks)

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

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The Periodic Table of Elements

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

1.0
H
hydrogen
1

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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

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

* Lanthanide series

* Actinide series

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