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Candidate surname

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Pearson BTEC
Level 3
Nationals
Diploma

Centre Number

Learner Registration Number

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Monday 20 January 2020

Afternoon (Time: 50 minutes)

Paper Reference **31627H/1C**

Applied Science

Unit 5: Principles and Applications of Science II

Chemistry

SECTION B: PROPERTIES AND USES OF SUBSTANCES

You will need:

A calculator and a 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 learner registration number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The exam comprises three papers worth 40 marks each.
Section A: Organs and systems (Biology).
Section B: Properties and uses of substances (Chemistry).
Section C: Thermal physics, materials and fluids (Physics).
- The total mark for this exam is 120.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- The periodic table of elements can be found at the back of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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

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 Calcium hydroxide, $\text{Ca}(\text{OH})_2$, is a typical metal hydroxide.

(a) Identify a chemical property of calcium hydroxide.

(1)

- A It is acidic.
- B It is amphoteric.
- C It is a base.
- D It is a catalyst.

(b) Give **one** use of calcium hydroxide.

(1)

(c) A technician wants to determine the heat transferred when calcium hydroxide dissolves in water.

The initial temperature of the water was 289.0 K.

(i) On the Kelvin scale of temperature, 0.0 K is -273.2°C .

Give the initial temperature of the water in $^\circ\text{C}$.

(1)

initial temperature of water = $^\circ\text{C}$

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(ii) The equation for heat transfer in a chemical process is:

heat transferred = mass of water \times specific heat capacity \times change in temperature

The mass of water used was 750 g.

The specific heat capacity of water is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$.

The initial temperature of the water was 289.0 K.

The final temperature of the water was 292.9 K.

Calculate the heat transferred when the calcium hydroxide dissolved.

Show your working.

(3)

heat transferred = J



(d) The enthalpy change of hydration is negative for positive ions and for negative ions.

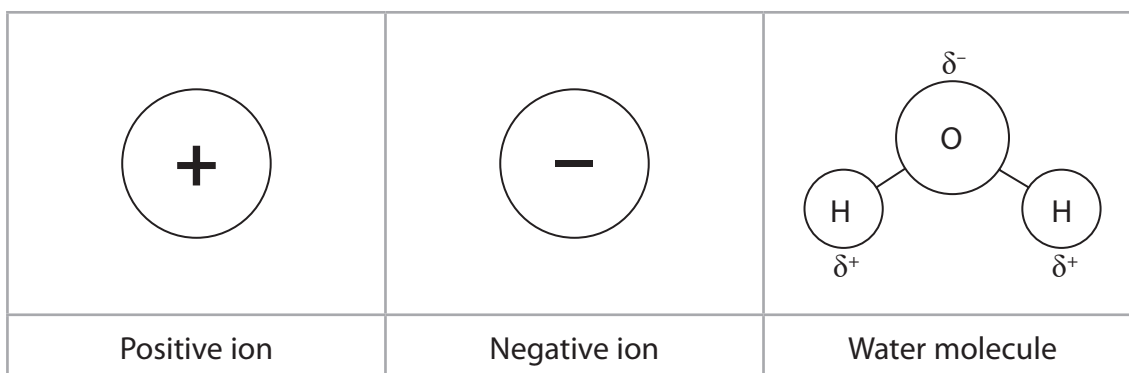


Figure 1

Explain why the enthalpy change of hydration for **any** ion with water is always negative.

You may use diagrams to support your answer.

(4)

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(Total for Question 1 = 10 marks)

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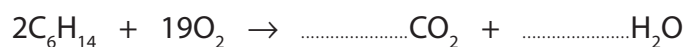
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2 Alkanes are used as fuels.

Petrol contains an alkane called hexane.

(a) (i) Add numbers to balance the chemical equation for the combustion of hexane. (2)



(ii) Identify the correct statement about the standard enthalpy change of combustion of hexane. (1)

- A An excess of oxygen gas is used.
- B Carbon monoxide and water are formed.
- C Conditions of 273 K and 100 kPa are used.
- D Two moles of hexane are burned.

(b) Hexane and two isomers of hexane are shown in Table 1.

Name	Structure
Hexane	<pre> H H H H H H H-C-C-C-C-C-C-H H H H H H H</pre>
W	<pre> H H CH₃ H H H-C-C-C-C-C-H H H H H H</pre>
2,2-dimethylbutane	<pre> H CH₃ H H H-C-C-C-C-H H CH₃ H H</pre>

Table 1

(i) Name isomer **W**. (1)

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(ii) Explain why hexane and 2,2-dimethylbutane are isomers.

(2)

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(iii) Identify and justify which isomer in Table 1 has the lowest boiling point.

(3)

Isomer.....

Justification.....

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(Total for Question 2 = 9 marks)

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3 The polymerisation of ethene is a commercially important process.

(a) The free radical addition mechanism for the polymerisation of ethene is shown in Table 2.

The initiation step and two propagation steps are complete.

The termination step is incomplete.

R—R represents the compound that produces free radicals.

Step	Mechanism equation
Initiation	$\text{R—R} \longrightarrow \text{R}\cdot \quad \cdot\text{R}$
Propagation	$\begin{array}{c} \text{R}\cdot \\ + \\ \text{CH}_2=\text{CH}_2 \end{array} \longrightarrow \text{RCH}_2\text{CH}_2\cdot$
Propagation	$\begin{array}{c} \text{RCH}_2\text{CH}_2\cdot \\ + \\ \text{CH}_2=\text{CH}_2 \end{array} \longrightarrow \text{RCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\cdot$
Termination	$\begin{array}{c} \text{RCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\cdot \\ + \\ \dots\dots\dots \end{array} \longrightarrow \dots\dots\dots$

Table 2

Complete the termination step in Table 2.

(2)

(b) Titanium(IV) chloride, TiCl_4 , can be used as a catalyst in the polymerisation of ethene.

TiCl_4 is made during the extraction of titanium from titanium(IV) oxide.

(i) Give the formula of titanium(IV) oxide.

(1)



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- (ii) During the mechanism for polymerisation, TiCl_4 combines with R and $\text{CH}_2=\text{CH}_2$ to form the intermediate species shown in Figure 2.

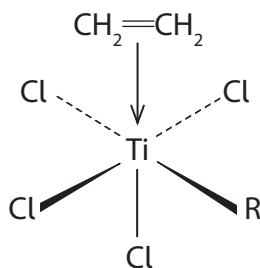


Figure 2

Identify the type of intermediate species shown in Figure 2.

(1)

- A anion
- B carbocation
- C complex
- D free radical

- (iii) State what the wedge shaped bond indicates about the positions of Ti and the R group in Figure 2.

(1)

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- (iv) Explain how the catalyst TiCl_4 lowers the amount of energy needed for the addition of $\text{CH}_2=\text{CH}_2$ to the R group.

You may refer to Figure 2 and Table 2 to support your answer.

(3)

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(Total for Question 3 = 8 marks)



4 Chemists use different ways to represent the atoms, bonds and shapes of organic molecules, such as alkenes.

Propene is an alkene and can be represented by the molecular formula C_3H_6 .

(a) Figure 3 shows the three carbon atoms in propene and the bonding between the atoms.

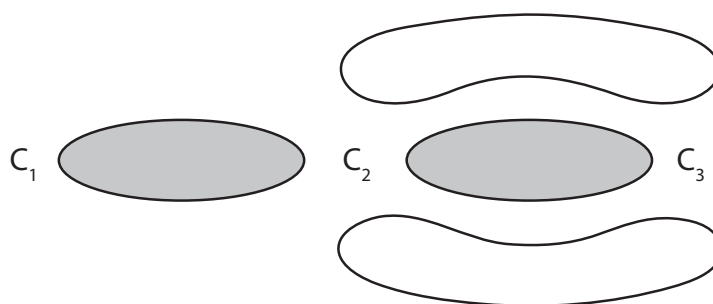


Figure 3

Describe the bonding shown between the carbon atoms in Figure 3.

(4)

Bonding between C_1 and C_2

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Bonding between C_2 and C_3

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(b) Figure 4 shows the displayed structural formula for propene.

The displayed structural formula does not show accurate bond lengths or bond angles.

Two of the bond angles are labelled **x** and **y**.

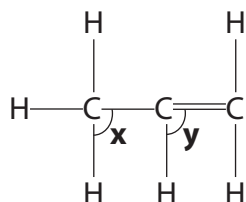


Figure 4

In the actual molecule, bond angle **y** is greater than bond angle **x**.

Explain why bond angle **y** is greater than bond angle **x**.

(2)

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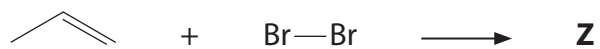
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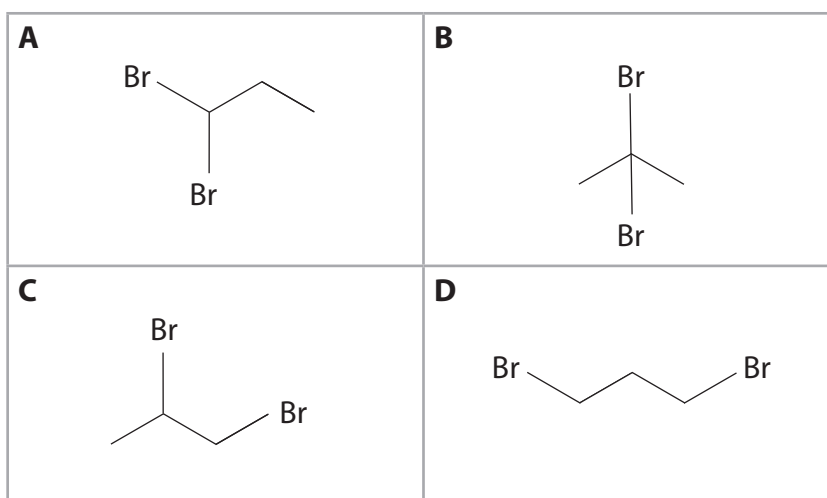


(c) The reaction of propene with bromine forms a single product **Z**.



Identify the skeletal formula of the product **Z**.

(1)



- A
- B
- C
- D

(Total for Question 4 = 7 marks)

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QUESTION 5 BEGINS ON THE NEXT PAGE.



5 Electrolysis is an important chemical process used to extract elements from their compounds.

The elements aluminium and chlorine are both extracted by electrolysis.

Table 3 shows some key information about the extraction of both elements.

	Extraction of aluminium	Extraction of chlorine
Electrolyte	Alumina	Brine
Chemical formula	Al_2O_3 (l)	NaCl (aq)
Product at anode	Oxygen	Chlorine
Product at cathode	Aluminium	Hydrogen
Other product formed	Carbon dioxide	Sodium hydroxide

Table 3

Compare the similarities and differences between the extraction of aluminium and the extraction of chlorine by electrolysis.

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Handwriting practice area with horizontal dotted lines.

(Total for Question 5 = 6 marks)

TOTAL FOR SECTION B = 40 MARKS



The Periodic Table of Elements

	1	2											3	4	5	6	7	0 (8)									
	(18)																										
	1.0 H hydrogen 1																										
	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> Key relative atomic mass atomic symbol name atomic (proton) number </div>																										
(1)	6.9 Li lithium 3	9.0 Be beryllium 4	23.0 Na sodium 11	24.3 Mg magnesium 12											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							
(2)															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							
(3)	39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	47.9 Ti titanium 22	50.9 V vanadium 23	50.9 V vanadium 23	54.9 Mn manganese 25	54.9 Mn manganese 25	55.8 Fe iron 26	55.8 Fe iron 26	58.9 Co cobalt 27	58.9 Co cobalt 27	58.9 Co cobalt 27	58.9 Co cobalt 27	65.4 Zn zinc 30	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	74.9 As arsenic 33	74.9 As arsenic 33	74.9 As arsenic 33	79.9 Br bromine 35	79.9 Br bromine 35	83.8 Kr krypton 36	
(4)	85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	91.2 Zr zirconium 40	92.9 Nb niobium 41	92.9 Nb niobium 41	95.9 Mo molybdenum 42	95.9 Mo molybdenum 42	101.1 Ru ruthenium 44	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45	112.4 Cd cadmium 48	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	118.7 Sn tin 50	121.8 Sb antimony 51	121.8 Sb antimony 51	121.8 Sb antimony 51	126.9 I iodine 53	126.9 I iodine 53	131.3 Xe xenon 54	
(5)	132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	178.5 Hf hafnium 72	180.9 Ta tantalum 73	180.9 Ta tantalum 73	183.8 W tungsten 74	183.8 W tungsten 74	190.2 Os osmium 76	190.2 Os osmium 76	192.2 Ir iridium 77	192.2 Ir iridium 77	192.2 Ir iridium 77	192.2 Ir iridium 77	200.6 Hg mercury 80	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	207.2 Pb lead 82	209.0 Bi bismuth 83	209.0 Bi bismuth 83	209.0 Bi bismuth 83	[210] At astatine 85	[210] At astatine 85	[222] Rn radon 86	
(6)	[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[261] Rf rutherfordium 104	[262] Db dubnium 105	[262] Db dubnium 105	[266] Sg seaborgium 106	[266] Sg seaborgium 106	[277] Hs hassium 108	[277] Hs hassium 108	[268] Mt meitnerium 109	[268] Mt meitnerium 109	[268] Mt meitnerium 109	[272] Rg roentgenium 111	[272] Rg roentgenium 111	[272] Rg roentgenium 111	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110
(7)	Elements with atomic numbers 112-116 have been reported but not fully authenticated																										
(8)	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	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71	175 Lu lutetium 71
(9)	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	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102	254 No nobelium 102

* Lanthanide series
* Actinide series

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