Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson BTEC Level 3 Nationals Diploma, Extended Diploma

Centre Number | Learner Registration Number

Monday 18 January 2021

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 must have:
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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P 6 7 5 0 7 R A 0 1 1 6

Pearson

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 Titanium can be manufactured from titanium(IV) oxide in two main stages.

The stages in the process are shown in Figure 1.

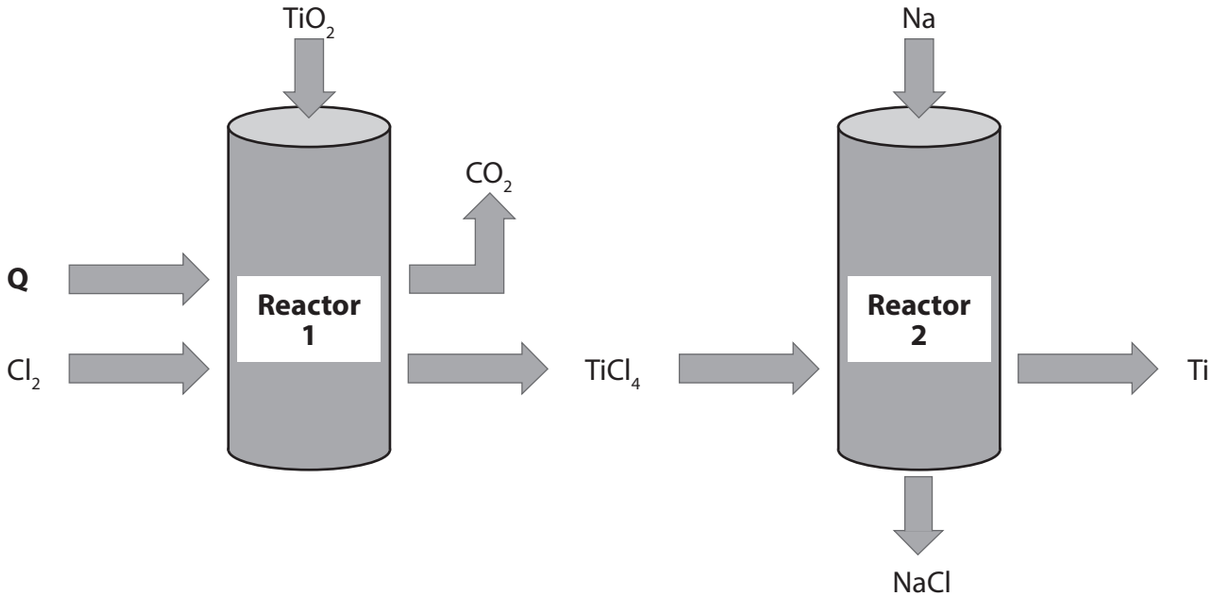

Figure 1

(a) Identify substance **Q** shown entering Reactor 1.

(1)

☒ **A** argon

☒ **B** carbon

☒ **C** chlorine

☒ **D** oxygen

(b) The reaction that takes place in Reactor 2 is:

$$TiCl_4 + 4Na \rightarrow 4NaCl + Ti$$

Identify the role of sodium in this reaction.

(1)

☒ **A** It catalyses the reaction.

☒ **B** It neutralises the titanium(IV) chloride.

☒ **C** It reduces the titanium(IV) chloride.

☒ **D** It stops reactions with gases in the air.

(c) Sodium chloride is produced in Reactor 2.

Electrolysis of sodium chloride produces chlorine.

(i) Describe how the electrolysis of sodium chloride produces chlorine.

(4)

(ii) Electrolysis can also be used to extract sodium from sodium chloride.

Using electrolysis to obtain titanium from titanium chloride is more difficult.

Figure 2a shows the reaction profile diagram for the extraction of titanium by electrolysis.

Figure 2b shows the reaction profile diagram for the extraction of sodium by electrolysis.

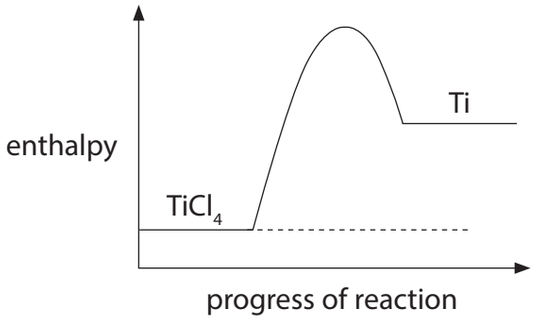

Figure 2a

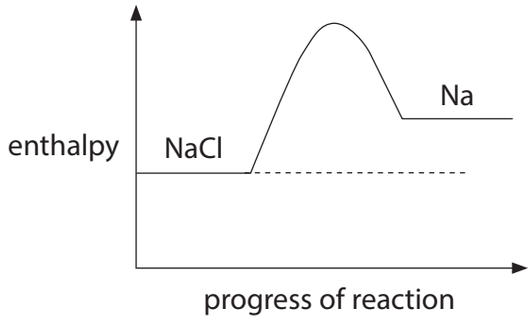

Figure 2b

Explain, using Figures 2a and 2b, why extracting titanium by electrolysis is more difficult than extracting sodium by electrolysis.

(2)

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(Total for Question 1 = 8 marks)

2 A learner investigated the temperature change when hydrochloric acid was added to a solution of sodium hydroxide.

(a) The initial temperature recorded was 15.0 °C.

The temperature change recorded was 3.4 °C.

The learner found that the reaction was exothermic.

(i) Calculate the final temperature.

(1)

final temperature = ... °C

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

Give the final temperature in Kelvin (K), using your answer to 2(a)(i).

(1)

final temperature = ... K

(b) (i) The learner added 25 cm^3 of hydrochloric acid to 25 cm^3 of sodium hydroxide solution.

The temperature change was 3.4° C.

The equation for enthalpy change (Q) is:

$$Q = m\ c\ \Delta T$$

$c = 4.18\ J\ g^{-1}\ °C^{-1}$

(assume 1 cm^3 = 1 g)

Calculate the enthalpy change for this reaction.

(3)

Show your working.

enthalpy change = ... J

(ii) The value calculated in (b)(i) is **not** a standard enthalpy change.

Give **two** reasons why.

(2)

1 .....

.....

2 .....

.....

(Total for Question 2 = 7 marks)

3 (a) Alkanes are hydrocarbons that have the general formula C_nH_{2n+2}

Write the molecular formula for an alkane with 16 carbon atoms.

(1)

.....

(b) One alkane has the molecular formula C_4H_{10}

Table 1 shows the two isomers of C_4H_{10}

Complete Table 1 with the name of isomer V and the structural formula of isomer W.

(2)

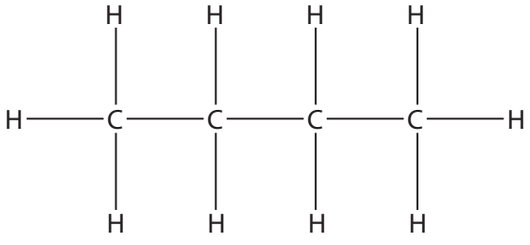
isomer	name	structural formula
V		
W	methylpropane	

Table 1

(c) C_4H_{10} molecules react with halogens.

This type of reaction is called a free radical substitution.

(i) Complete Sentence 1 to give a definition of a free radical.

(1)

A free radical is a species with an unpaired ..... .

Sentence 1

(ii) The free radical substitution of C_4H_{10} with bromine begins with an initiation step.

The initiation step for the reaction is:

$$Br\text{-}Br \rightarrow Br\bullet + Br\bullet$$

Identify the type of bond fission shown in the initiation step.

(1)

- ☒ **A** asymmetric
- ☒ **B** electrophilic
- ☒ **C** heterolytic
- ☒ **D** homolytic

(iii) The two propagation steps for the reaction are shown in Table 2.

propagation steps	$Br\bullet + C_4H_{10} \rightarrow \mathbf{X} + \mathbf{Y}$
	$\mathbf{Y} + \mathbf{Z} \rightarrow C_4H_9Br + Br\bullet$

Table 2

Give the formula of X, Y and Z shown in Table 2.

(3)

X = ...

Y = ...

Z = ...

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(iv) The reaction ends with a termination step.

State what happens to the free radicals in a termination step.

(1)

(d) C_4H_{10} is a gas at room temperature.

C_8H_{18} is another alkane but is a liquid at room temperature.

Explain why C_4H_{10} is a gas but C_8H_{18} is a liquid at room temperature.

(3)

(Total for Question 3 = 12 marks)

4 A carbon atom must hybridise its outer s and p orbitals before the atom can form covalent bonds.

(a) Table 3 shows diagrams of the orbitals for sp and sp^3 hybridisation.

Draw a diagram in Table 3 to show the orbitals in sp^2 hybridisation, including the bond angle.

(2)

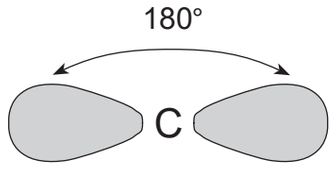
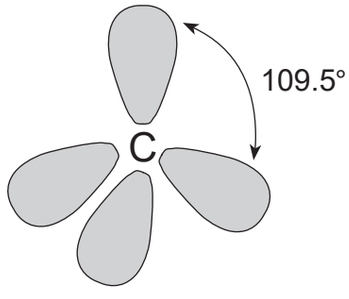
hybridisation	diagram of orbitals
sp	
sp^2	C
sp^3	

Table 3

(b) Table 4 shows the number of electrons in the orbitals for sp^3 and sp^2 hybridised carbon atoms.

(i) Complete Table 4 to show the number of electrons in an sp hybridised carbon atom.

(1)

	number of electrons in 2p orbitals	**number of electrons in hybrid orbitals**
sp^3 hybridised carbon	0	4
sp^2 hybridised carbon	1	3
sp hybridised carbon		

Table 4

(ii) Hybridisation can also be shown using electron-in-box diagrams.

Figure 3 shows the electron-in-box diagrams for sp^3 and sp^2 hybridisation.

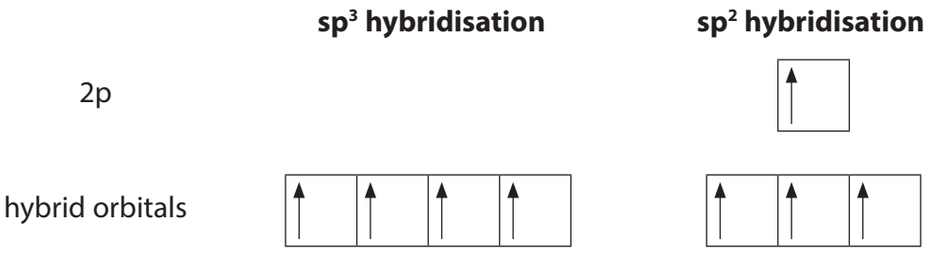


Figure 3

Explain why sp^3 hybridisation can only form single bonds but sp^2 hybridisation can form double bonds and single bonds.

You should refer to Figure 3 to support your answer.

(4)

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(Total for Question 4 = 7 marks)

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5 Figure 4 shows how $C_{10}H_{22}$ can be cracked to form two products.

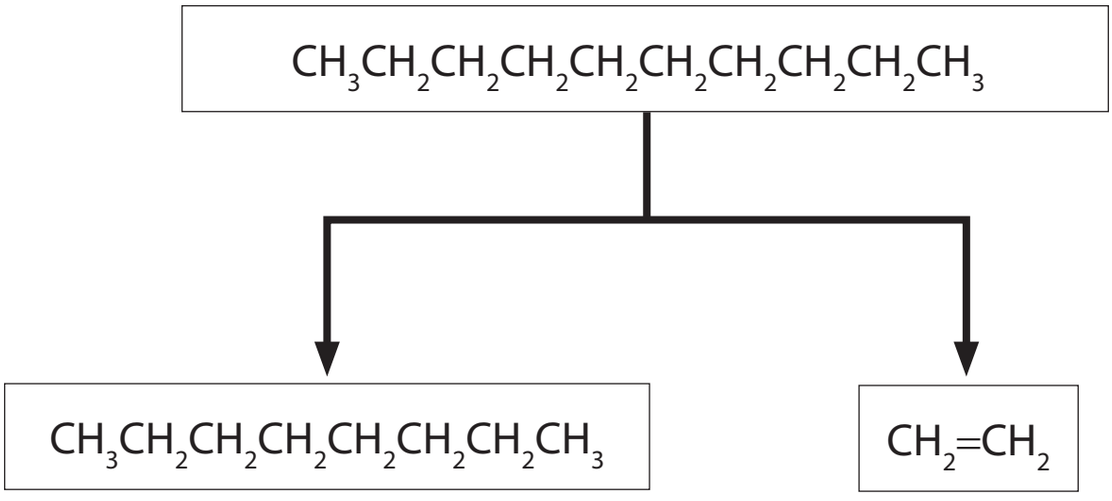

Figure 4

Discuss the commercial importance of this reaction and of the two products.

Your answer should include the:

- purpose of the reaction shown in Figure 4
- uses of the two products
- equations that show the use of the two products.

(6)

(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										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

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