Pearson BTEC Level 3 Nationals Diploma, Extended Diploma

Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Learner Registration Number

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 ▶

P64271RA

1/1/1/1/1/1/1/1/1

P 6 4 2 7 1 R A 0 1 1 2

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 Alumina is the common name for aluminium oxide (Al_2O_3).

Aluminium oxide is the raw material used for the manufacture of aluminium.

(a) Identify the process used to extract aluminium from aluminium oxide.

(1)

☒ **A** catalysis

☒ **B** combustion

☒ **C** electrolysis

☒ **D** hydration

(b) Most metal oxides are bases but aluminium oxide is amphoteric.

(i) Complete the ionic equation for the reaction of aluminium oxide with hydrochloric acid.

(2)

$$Al_2O_3 + \text{.....}H^+ \longrightarrow \text{.....}Al^{3+} + 3H_2O$$

(ii) Give the missing words A and B in Paragraph 1.

(2)

When aluminium oxide is reacted with hydrogen ions, the aluminium oxide dissolves because it acts as a base.

However, when aluminium oxide reacts with .....A..... ions, the aluminium oxide dissolves because it acts as an .....B..... .

This shows that aluminium oxide is amphoteric.

Paragraph 1

A .....

B .....

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(c) Aluminium oxide is an ionic compound.

Aluminium oxide is a refractory material because it is resistant to high temperature.

Explain why the structure of aluminium oxide makes the compound resistant to high temperature.

(4)

(Total for Question 1 = 9 marks)

2 Enthalpy changes are quoted under standard conditions in reference books.

(a) Identify the temperature and pressure used for standard conditions.

Draw a line from the condition to the value.

(2)

condition	value
	25
temperature (in K)	100
	201
pressure (in kPa)	298
	373

(b) A reference book gives the standard enthalpy change of formation for hydrogen gas as 0 kJ mol^{-1}.

Explain why the standard enthalpy change of formation for hydrogen gas is 0 kJ mol^{-1}.

(2)

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.....

(c) Hydrogen gas can be produced from methane and steam.

$$CH_4(g) + 2H_2O(g) \longrightarrow CO_2(g) + 4H_2(g)$$

The enthalpy change of the reaction ($\Delta H_r^\ominus$) can be calculated from standard enthalpy change of formation data, using the equation:

$$\Delta H_r^\ominus = \text{sum of all } \Delta H_f^\ominus \text{ (products)} - \text{sum of all } \Delta H_f^\ominus \text{ (reactants)}$$

Table 1 shows the standard enthalpy change of formation for methane, steam, carbon dioxide and hydrogen.

	reactants		**products**	
substance	CH_4 (g)	H_2O (g)	CO_2 (g)	H_2 (g)
$\Delta H_f^\ominus$/ kJ mol^{-1}	–75	–242	–396	0

Table 1

(i) Calculate the value of $\Delta H_r^\ominus$ for the reaction of methane with steam, using the $\Delta H_f^\ominus$ data in Table 1.

Show your working, using the equation or by any other method.

(4)

$\Delta H_r^\ominus$ = ... kJ mol^{-1}

(ii) Hydrogen gas can also be manufactured by electrolysis.

Name an inorganic compound that can be dissolved in water to manufacture hydrogen by electrolysis.

(1)

.....

.....

(Total for Question 2 = 9 marks)

3 (a) C_4H_8 has four isomers that are alkenes.

The skeletal formulae of three of the four alkenes are shown in Table 2.

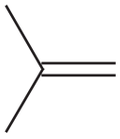
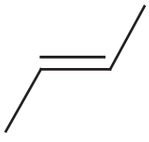
	
V	**W**
	
X	**Y**

Table 2

(i) Name isomer **V**, using IUPAC rules.

(1)

.....

(ii) Draw the skeletal formula of alkene **Y** in Table 2.

(1)

(iii) **W** and **X** in Table 2 are geometric stereoisomers.

Explain why **W** and **X** are geometric stereoisomers but **V** is not.

(3)

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(b) Cracking is a commercially important method for producing a mixture of short-chain alkanes and alkenes from long-chain hydrocarbons.

The equation for a cracking reaction is shown.

The products formed are ethene, propene and alkane **Z**.

$$C_{15}H_{32} \longrightarrow 2C_2H_4 + C_3H_6 + \mathbf{Z}$$

(i) Identify alkane **Z**.

(1)

- ☒ **A** C_7H_{16}
- ☒ **B** C_7H_{18}
- ☒ **C** C_8H_{16}
- ☒ **D** C_8H_{18}

(ii) State **one** use of short-chain alkanes.

(1)

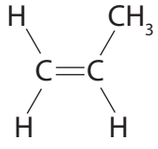
.....

(iii) Give **one** way to increase the yield of alkenes in the product mixture.

(1)

.....

(iv) The structural formula of propene is



The main use of propene is to manufacture the polymer poly(propene).

Draw the repeat unit of poly(propene).

(2)

(Total for Question 3 = 10 marks)

4 Sulfur dioxide can be converted into sulfur trioxide in the Contact process.

The equation for the Contact process is

$$2SO_2\,(g) \;+\; O_2\,(g) \;\rightleftarrows\; 2SO_3\,(g)$$

The Contact process uses vanadium(V) oxide as a catalyst.

Figure 1 shows the reaction profile diagram for the Contact process.

E_a is the activation energy and ΔH is the enthalpy change for the catalysed forwards reaction.

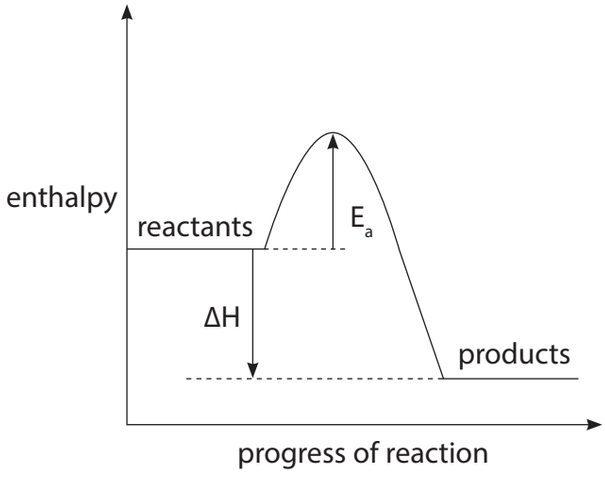


Figure 1

(a) Identify the type of process that E_a and ΔH represent in Figure 1.

(1)

		E_a	ΔH
☒	**A**	Endothermic	Endothermic
☒	**B**	Endothermic	Exothermic
☒	**C**	Exothermic	Endothermic
☒	**D**	Exothermic	Exothermic

(b) The catalyst is removed.

Draw, on Figure 1, the shape of the reaction profile without the catalyst.

(2)

(c) Vanadium(V) oxide catalyses the Contact process in two steps.

$$SO_2 + V_2O_5 \longrightarrow SO_3 + V_2O_4$$

$$V_2O_4 + \tfrac{1}{2}O_2 \longrightarrow V_2O_5$$

Figure 2

Explain how the equations in Figure 2 show that vanadium(V) oxide acts as a catalyst.

(3)

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(Total for Question 4 = 6 marks)

5 Chloroethane can be made either from ethene or ethane.

The equations and the organic intermediates involved in the reactions are shown in Figures 3 and 4.

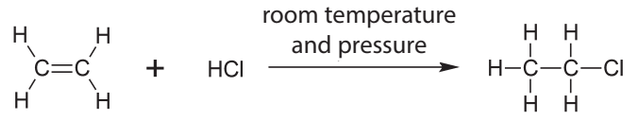
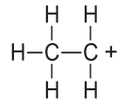
Ethene reaction	Intermediate
	

Figure 3

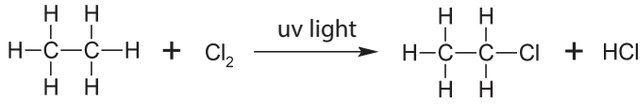
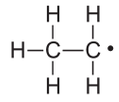
Ethane reaction	Intermediate
	

Figure 4

Compare the **two** reactions.

In your answer you should refer to:

- reactants, products and intermediates
- reaction type and conditions.

(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)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									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