Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson BTEC Level 3 Nationals Diploma

Centre Number | | | | | | |

Learner Registration Number | | | | | | | | |

Tuesday 22 January 2019

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 ▶

P61807A

1/1/1/1/1/1/1/1/C2

P 6 1 8 0 7 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 Aluminium is one of the most abundant elements in the Earth's crust.

Aluminium is extracted by electrolysis from alumina.

Figure 1 shows a diagram of the Hall–Héroult process used to electrolyse alumina.

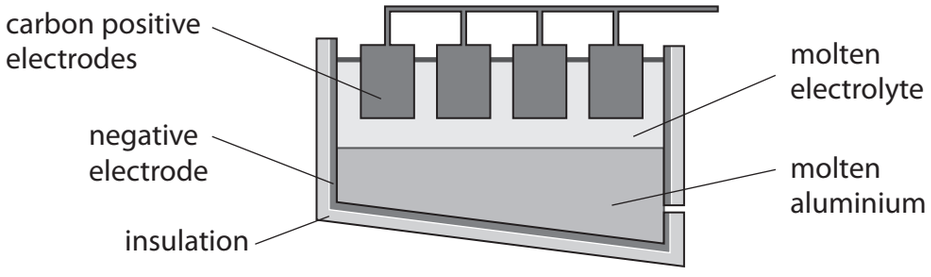


Figure 1

(a) Identify the chemical formula of alumina.

(1)

☒ **A** AlO

☒ **B** AlO_2

☒ **C** Al_2O

☒ **D** Al_2O_3

(b) (i) The alumina is dissolved in a substance to form the electrolyte.

Identify the substance in which the alumina is dissolved.

(1)

- ☒ **A** Bauxite
- ☒ **B** Cryolite
- ☒ **C** Sodium hydroxide
- ☒ **D** Water

(ii) The melting point of alumina is 2072 °C.

Explain why the alumina is dissolved rather than melted before it is electrolysed.

(2)

.....

.....

.....

.....

(c) Write the balanced half-equation for the production of aluminium at the negative electrode.

(2)

..... + ... → Al

(d) Explain why the carbon positive electrodes in Figure 1 need to be replaced regularly.

(2)

.....

.....

.....

.....

(Total for Question 1 = 8 marks)

2 Ammonia, NH_3, is used to make fertilisers.

Ammonia is made by the Haber process.

The equation for the reaction is

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

An iron catalyst is used in the reaction to lower the activation energy.

Figure 2 shows the enthalpy profile for the uncatalysed reaction.

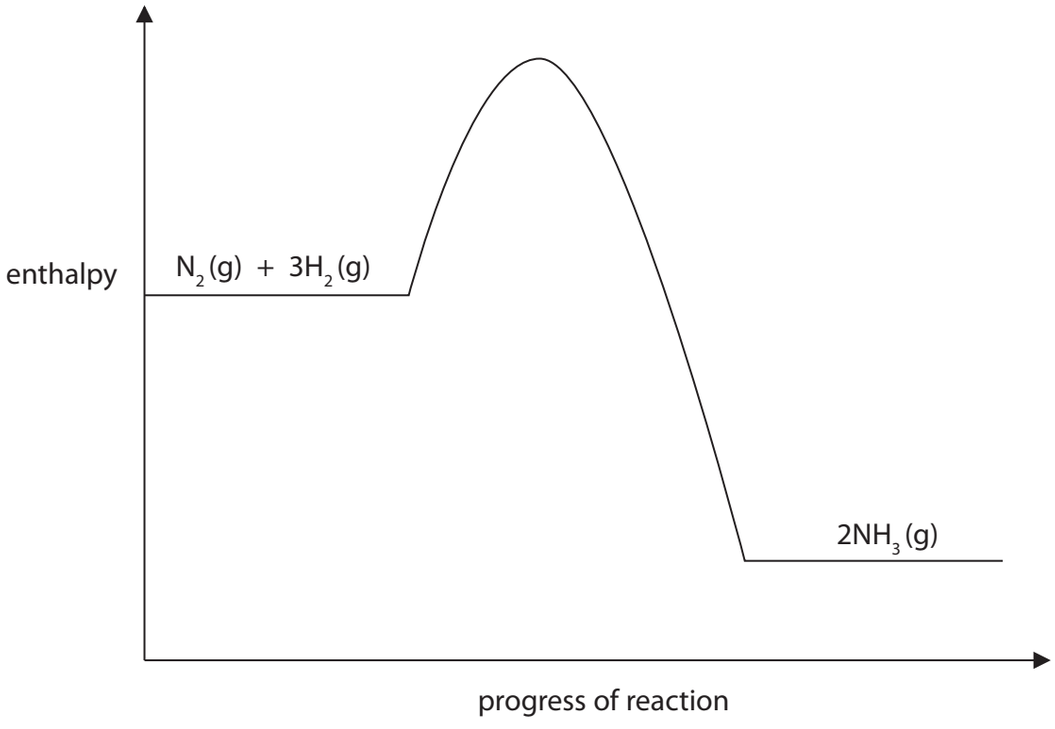


Figure 2

(a) Draw, on the diagram in Figure 2, the enthalpy profile when the reaction is catalysed.

(1)

(b) Explain the effect of using a catalyst in the Haber process.

(4)

(Total for Question 2 = 5 marks)

3 Sodium chloride is an ionic compound that dissolves in water.

The solution contains aqueous ions Na^+ (aq) and Cl^- (aq).

A concentrated aqueous solution of sodium chloride is known as brine.

(a) When brine is electrolysed, three useful products are formed: hydrogen, chlorine and sodium hydroxide.

Describe where each product is formed during the electrolysis of brine.

(3)

.....

.....

.....

.....

.....

.....

(b) The equations for the standard enthalpy change of hydration for sodium and chloride ions are shown below.

$$Na^+(g) + (aq) \rightarrow Na^+(aq)$$

$$Cl^-(g) + (aq) \rightarrow Cl^-(aq)$$

Complete the definition of the standard enthalpy change of hydration.

(2)

The enthalpy change when 1 mole of ions in the ..... state are dissolved in water to infinite dilution under standard conditions (..... kPa and 298 K).

(c) Standard enthalpy changes of hydration can be used as part of an energy cycle to predict the solubility of an ionic compound, such as sodium chloride, in water.

The energy cycle for the dissolving of sodium chloride in water is shown in Figure 3.

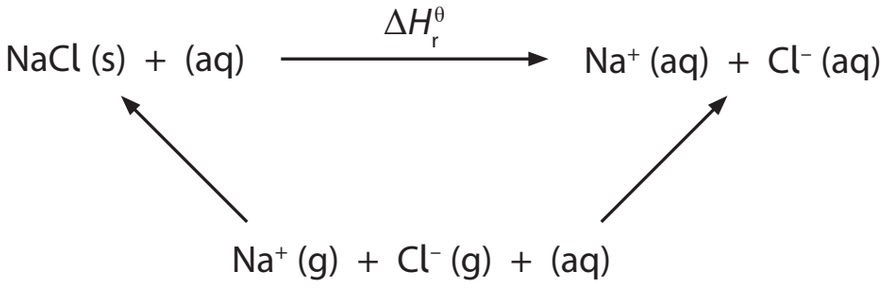


Figure 3

Table 1 shows literature values for some standard enthalpy changes (ΔH^θ) involved in the energy cycle.

Equation	ΔH^θ / kJ mol^{-1}
$Na^+(g) + (aq) \rightarrow Na^+(aq)$	−418
$Cl^-(g) + (aq) \rightarrow Cl^-(aq)$	−338
$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$	−760

Table 1

Calculate the standard enthalpy change (ΔH_r^θ) for dissolving sodium chloride in water, using the energy cycle in Figure 3 and the data in Table 1.

(3)

Show your working.

ΔH_r^θ = ... kJ mol^{-1}

(d) A student wanted to find an experimental value for the enthalpy change when sodium chloride is dissolved in water.

(i) The student dissolved some sodium chloride in 200 cm^3 of water at room temperature.

The temperature of the water dropped by 2.5 °C when the sodium chloride had dissolved.

Calculate the heat energy change for dissolving sodium chloride in water.

heat energy change = mass × specific heat capacity × temperature change

specific heat capacity of water = 4.18 $kJ\,kg^{-1}\,°C^{-1}$

(3)

Show your working.

heat energy change = ... kJ

(ii) The student wanted to compare their experimental value against an answer calculated from literature data.

Give **one** reason why it would not be valid to compare the heat change value in (d)(i) with the value calculated in (c).

(1)

.....

.....

(Total for Question 3 = 12 marks)

4 Bromoalkanes are industrially important as solvents for glues and for degreasing surfaces.

They do not occur naturally and are produced from the reaction of hydrocarbons with bromine or hydrogen bromide.

(a) Alkanes can react with bromine to form bromoalkanes but only when exposed to ultraviolet light.

The reaction of an alkane with bromine is

$$CH_3CH_2CH_3 + Br_2 \rightarrow CH_3CH_2CH_2Br + HBr$$

Describe how ultraviolet light causes the reaction to begin.

(2)

.....

.....

.....

.....

(b) Propene reacts with hydrogen bromide to produce two possible bromoalkanes.

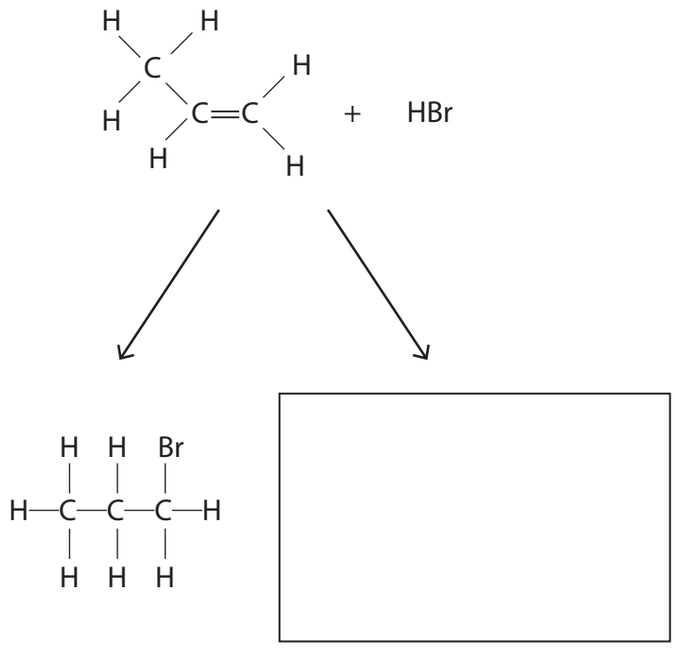


Figure 4

(i) Draw the displayed structural formula of bromoalkane **Y** in the box in Figure 4.

(1)

(ii) Identify the reason that propene is able to form two bromoalkanes.

(1)

☒ **A** It has a symmetrical structure.

☒ **B** It has an asymmetrical structure.

☒ **C** It has both cis and trans isomers.

☒ **D** It has hybridised carbon atoms.

(iii) Identify the name of bromoalkane **X** in Figure 4.

(1)

☒ **A** 1-bromopropane

☒ **B** 1-bromopropene

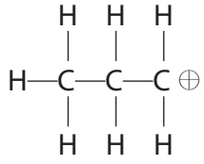
☒ **C** 3-bromopropane

☒ **D** 3-bromopropene

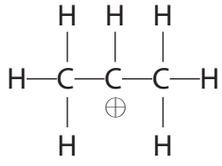
(iv) Propene reacts with hydrogen bromide by an electrophilic addition mechanism.

During the reaction mechanism, a carbocation is formed.

The two possible carbocations that can form are shown below.



carbocation A



carbocation B

Figure 5

Compare the stability of carbocation A with carbocation B.

(4)

(Total for Question 4 = 9 marks)

5 Ethanol can be used as a biofuel.

Ethanol can be manufactured by two different methods.

Method	Hydration of ethene	Fermentation
reaction	$C_2H_4 + H_2O \rightleftharpoons CH_3CH_2OH$	$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$
raw materials	ethene and water	glucose
source	crude oil	plant material
temperature	500 K	310 K
catalyst	phosphoric acid	yeast
yield	5%	10%
process	continuous	batch

Table 2

Discuss the advantages and disadvantages of the manufacture of ethanol by the hydration of ethene, using the information in Table 2.

(6)

(Total for Question 5 = 6 marks)

TOTAL FOR SECTION B = 40 MARKS

BLANK PAGE

BLANK PAGE

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(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							

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