Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 26 May 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

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6/6/6/4/

P 4 8 3 8 2 A 0 1 2 4

Pearson

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

1 Sea water contains 2.7 mg of sulfate ions per kilogram.

What is the concentration of sulfate ions in parts per million by mass?

☒ **A** 2.7×10^{-6}

☒ **B** 2.7×10^{-3}

☒ **C** 2.7

☒ **D** 2.7×10^{3}

(Total for Question 1 = 1 mark)

2 How many **ions** are in 284 g of sodium sulfate, Na_2SO_4?

Avogadro constant = 6.0×10^{23} mol^{-1}

Molar mass of sodium sulfate = 142 g mol^{-1}

☒ **A** 1.2×10^{24}

☒ **B** 2.4×10^{24}

☒ **C** 3.6×10^{24}

☒ **D** 8.4×10^{24}

(Total for Question 2 = 1 mark)

3 Calculate the empirical formula of the compound with the percentage composition by mass: Li = 17.9%; P = 26.8%; O = 55.3%

Molar masses / g mol^{-1} Li = 6.9, P = 31.0, O = 16.0

☒ **A** $Li_2P_3O_6$

☒ **B** Li_3PO_3

☒ **C** $LiPO_3$

☒ **D** Li_3PO_4

(Total for Question 3 = 1 mark)

4 What is the empirical formula of the oxide formed when 2.6 g of chromium produces 3.8 g of chromium oxide?

Molar masses / g mol^{-1} Cr = 52.0, O = 16.0

☒ **A** CrO

☒ **B** CrO_2

☒ **C** Cr_2O_3

☒ **D** Cr_3O_4

(Total for Question 4 = 1 mark)

5 Consider the reaction

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What is the maximum volume, in dm^3, of sulfur trioxide that could be obtained when 0.5 dm^3 of sulfur dioxide is mixed with 1 dm^3 of oxygen, under suitable conditions?

All measurements are made at the same temperature and pressure.

☒ **A** 0.5

☒ **B** 1.5

☒ **C** 2.0

☒ **D** 2.5

(Total for Question 5 = 1 mark)

6 Identify the atom with two unpaired electrons in its lowest energy state (ground state).

☒ **A** Be

☒ **B** C

☒ **C** Cl

☒ **D** Ca

(Total for Question 6 = 1 mark)

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

7 Which ion has the **largest** ionic radius?

☒ **A** Ca^{2+}

☒ **B** Cl^-

☒ **C** K^+

☒ **D** S^{2-}

(Total for Question 7 = 1 mark)

8 The compound with the greatest covalent character is

☒ **A** NaF

☒ **B** NaI

☒ **C** AlF_3

☒ **D** AlI_3

(Total for Question 8 = 1 mark)

9 What is the sequence of the orbitals from which electrons are removed in the first four ionisations of boron?

	1st Ionisation	2nd Ionisation	3rd Ionisation	4th Ionisation
☒ **A**	1s	1s	2s	2s
☒ **B**	1s	2s	2s	2p
☒ **C**	2p	2s	2s	1s
☒ **D**	2p	2s	1s	1s

(Total for Question 9 = 1 mark)

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

10 Calcium chloride can be prepared by reacting calcium carbonate with dilute hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a) The ionic equation for the reaction is

(1)

☒ **A** $Ca^{2+}(s) + 2Cl^-(aq) \rightarrow CaCl_2(aq)$

☒ **B** $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

☒ **C** $CO_3^{2-}(s) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

☒ **D** $CaCO_3(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

(b) An excess of calcium carbonate is used in the preparation. The sequence of processes needed to obtain crystals of calcium chloride from the reaction mixture is

(1)

☒ **A** filtering, concentrating the solution, slowly evaporating.

☒ **B** filtering, slowly evaporating, distilling.

☒ **C** concentrating the solution, filtering, distilling.

☒ **D** concentrating the solution, slowly evaporating, filtering.

(c) The excess calcium carbonate was added to 100 cm^3 of 2.00 mol dm^{-3} hydrochloric acid. The mass of calcium chloride crystals obtained was 10.4 g.

Molar mass of calcium chloride crystals, $CaCl_2.2H_2O$ = 147 g mol^{-1}.

The percentage yield, by mass, of calcium chloride crystals is

(1)

☒ **A** 71.2

☒ **B** 70.7

☒ **C** 35.4

☒ **D** 17.7

(Total for Question 10 = 3 marks)

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

11 Which of the following series shows the elements in order of increasing melting temperature?

☒ **A** Li, Na, K

☒ **B** Al, Si, P

☒ **C** Na, Mg, Al

☒ **D** S, Cl, Ar

(Total for Question 11 = 1 mark)

12 Consider the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI\ (g) \qquad \Delta H = -9.0\ kJ\,mol^{-1}$$

The bond energy of H—H = 436 $kJ\,mol^{-1}$

The bond energy of H—I = 298 $kJ\,mol^{-1}$

It can be deduced that the bond energy of I—I, in $kJ\,mol^{-1}$, is

☒ **A** 75.5

☒ **B** 84.5

☒ **C** 151

☒ **D** 169

(Total for Question 12 = 1 mark)

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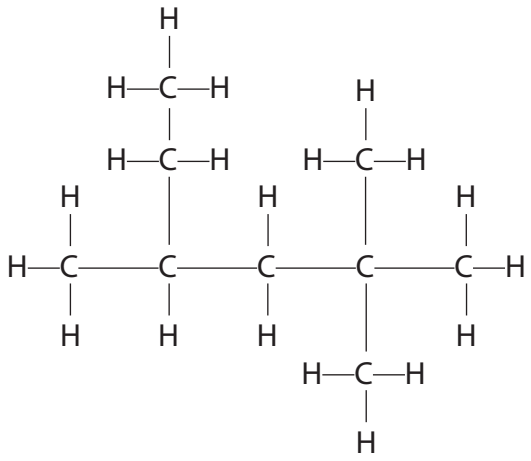
13 What is the systematic name for the hydrocarbon shown?



- ☒ **A** 2,2-dimethyl-4-ethylpentane
- ☒ **B** 2-ethyl-4,4-dimethylpentane
- ☒ **C** 3,5,5-trimethylhexane
- ☒ **D** 2,2,4-trimethylhexane

(Total for Question 13 = 1 mark)

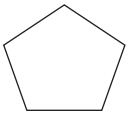
14 Which compound has *E-Z* isomers?

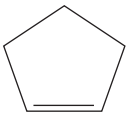
- ☒ **A** but-1-ene
- ☒ **B** but-2-ene
- ☒ **C** 1,1-dichloroethene
- ☒ **D** 2-methylbut-2-ene

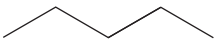
(Total for Question 14 = 1 mark)

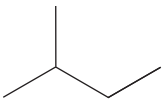
Use this space for any rough working. Anything you write in this space will gain no credit.

15 Which compound has an empirical formula different from its molecular formula?

☒ **A** 

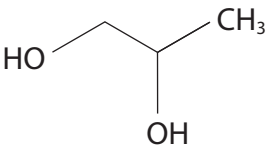
☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 15 = 1 mark)

16 Which reagent reacts with propene to form this compound?



☒ **A** hydrogen peroxide solution

☒ **B** oxygen and water

☒ **C** aqueous sodium hydroxide

☒ **D** acidified potassium manganate(VII)

(Total for Question 16 = 1 mark)

17 Propene reacts with hydrogen bromide to form

☒ **A** a mixture of 1-bromopropane and 2-bromopropane

☒ **B** 1,2-dibromopropane

☒ **C** 2-bromopropan-1-ol

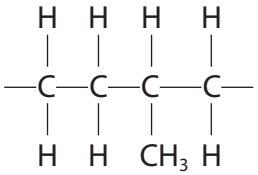
☒ **D** 1-bromopropan-2-ol

(Total for Question 17 = 1 mark)

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

18 Copolymers are formed from two different monomers.

The repeat unit of a copolymer is



This copolymer is formed from ethene and

☒ **A** propane.

☒ **B** propene.

☒ **C** 2-methylbutane.

☒ **D** 2-methylbut-1-ene.

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

19 A sample of an element, **X**, was extracted from a meteorite.

The table gives the percentage abundance of the isotopes of **X** obtained from the mass spectrum of the sample.

m/*e*	% abundance
54	6.10
56	92.0
57	1.90

(a) (i) Calculate the relative atomic mass of the element in this sample.

Give your answer to **three** significant figures.

(2)

(ii) Identify **X** and hence give the numbers of subatomic particles present in the species at *m*/*e* = 56 in the mass spectrum.

(2)

X .....

Number of particles present in the species at *m*/*e* = 56		
protons	electrons	neutrons

(iii) A peak at $m/e = 28$ was also detected in the mass spectrum of **X**.

Identify the species which produced this peak.

(1)

(iv) Explain why the three isotopes of **X** have the same chemical properties.

(2)

(b) (i) Outline how a solid sample of element **X** is converted into ions in a mass spectrometer.

(2)

(ii) Following the formation of ions, there are three steps in the production of a spectrum in the mass spectrometer.

Name the three steps **in order** and state how the first two are carried out.

(3)

(Total for Question 19 = 12 marks)

20 (a) The element sodium and the compound sodium bromide are both solid at room temperature.

(i) Name the type of bonding in sodium and explain how this bonding holds the structure together.

(2)

(ii) Name the type of bonding in sodium bromide and explain how this bonding holds the structure together.

(1)

(iii) The table shows the melting temperatures of sodium and of sodium bromide.

Substance	Sodium	Sodium bromide
Melting temperature / K	371	1020

What can you deduce from these data about the bonding in the two substances?

(1)

(iv) Name **one** physical property, other than melting or boiling temperature, in which sodium and sodium bromide differ due to the difference in their bonding.

Describe how this property differs for each of the two substances.

(2)

(b) The ammonium ion, NH_4^+, contains covalent bonds and a dative covalent bond.

(i) Describe the difference between a covalent bond and a dative covalent bond.

(2)

(ii) Draw a dot and cross diagram for an ammonium ion. Use the symbol **x** for electrons from the hydrogen atoms and ● for electrons from the outer shell of the nitrogen atom.

(2)

(iii) Suggest how an electron density map of ammonium chloride would provide evidence for the presence of ions in the compound.

(1)

(Total for Question 20 = 11 marks)

21 (a) The table below shows some of the ionisation energies of magnesium.

	First	Second	Third	Fourth	Fifth
Ionisation energy / kJ mol^{-1}	738	1451		10541	13629

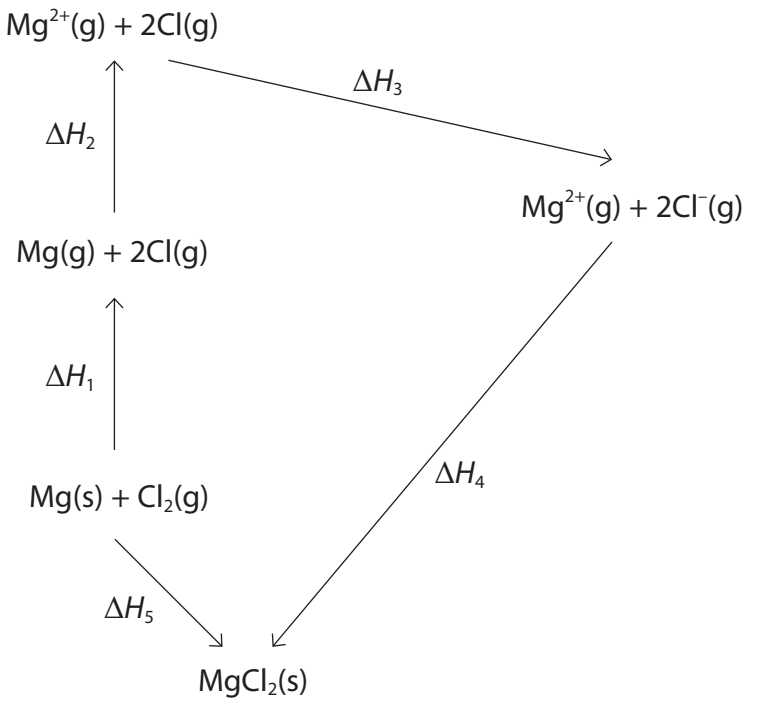
(i) Complete the table by predicting a value for the **third** ionisation energy of magnesium.

(1)

(ii) Write the equation for the third ionisation of magnesium. Include state symbols.

(2)

(b) A version of the Born-Haber cycle for magnesium chloride is shown below.



(i) Identify the enthalpy changes from the Born-Haber cycle by completing the table.

ΔH_1 is the sum of **two** enthalpy changes and you should give both.

(3)

Enthalpy change	Identity of enthalpy change
ΔH_1	
ΔH_3	
ΔH_5	

(ii) Use the data in (a) to calculate the value of ΔH_2.

(1)

$\Delta H_2 =$

(iii) Use your answer to (ii) and the following data to calculate the lattice energy of magnesium chloride, ΔH_4.

Enthalpy change	Value of enthalpy change / kJ mol^{-1}
ΔH_1	+391.1
ΔH_3	–697.6
ΔH_5	–641.3

(2)

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(c) A similar Born-Haber cycle can be drawn for calcium chloride.

*(i) In the calcium chloride cycle, the corresponding value for ΔH_2 is less positive. Explain why this is so.

(2)

*(ii) Explain why the value for the lattice energy, ΔH_4, is less negative for calcium chloride than for magnesium chloride.

(2)

(Total for Question 21 = 13 marks)

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22 Sodium hydrogencarbonate decomposes on heating to form sodium carbonate, carbon dioxide and water.

Reaction 1 $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$

(a) Suggest why it is difficult to measure the enthalpy change of this reaction directly.

(1)

(b) The enthalpy change can be measured indirectly using the enthalpy changes for the following two reactions and applying Hess's Law.

Reaction 2 $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

Reaction 3 $Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$.

An experiment was carried out to measure the enthalpy change of **Reaction 2**.

100 cm^3 of 1.25 mol dm^{-3} hydrochloric acid was placed in a polystyrene beaker with capacity 200 cm^3. The initial temperature of the acid was 21.5 °C.

8.00 g of solid sodium hydrogencarbonate was added, a lid was placed on the beaker and the mixture was stirred. The lowest temperature of the mixture was 14.2 °C.

(i) Explain why the beaker used in this experiment is large.

(1)

(ii) Show by calculation that the hydrochloric acid is present in excess.

(2)

(iii) Calculate the energy transferred and hence the enthalpy change of the reaction in kJ mol^{-1}.

Include a sign and units in your answer.

Use the equation: Energy transferred (J) = 100 × 4.18 × temperature change.

(3)

(iv) The enthalpy change for **Reaction 3** was found to be –36.3 kJ mol^{-1}.

Complete the Hess cycle by adding the appropriate arrows and formulae to the outline.

Use your completed cycle to calculate the enthalpy change for **Reaction 1**.

(4)

$2NaHCO_3(s)$	**Reaction 1** ⟶	$Na_2CO_3(s) + H_2O(l) + CO_2(g)$

ΔH for **Reaction 1** = ... kJ mol^{-1}

(Total for Question 22 = 11 marks)

23 (a) Ethane reacts with chlorine in the presence of ultraviolet light forming chloroethane, C_2H_5Cl and other products.

(i) Ultraviolet light causes **homolytic fission** of chlorine molecules.

Draw a dot and cross diagram of a chlorine molecule and use it to explain what happens to the molecule when homolytic fission occurs, naming the species produced.

(2)

(ii) Write the equations for the **two** propagation steps which occur in the reaction producing chloroethane.

(2)

Equation 1:

Equation 2:

(iii) Write the equation for the termination step which produces a hydrocarbon as a product in this reaction.

(1)

(b) Ethene also reacts with chlorine but by a different mechanism.

*(i) Describe how the π bond in ethene forms and explain why this bond causes ethene to take part in addition reactions with halogens.

(2)

.....

.....

.....

.....

.....

.....

*(ii) Write the mechanism for the reaction of ethene with chlorine.

Use curly arrows to show movements of electron pairs.

(3)

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(iii) Name the product of the reaction of chlorine with ethene.

(1)

.....

(c) The halogenoalkene,1-chloroethene, is used to make a widely used polymer, poly(chloroethene), commonly known as PVC.

Write a balanced equation for the polymerisation of 1-chloroethene to PVC.

Use displayed formulae to show the bonds in both the monomer and the polymer.

(2)

(Total for Question 23 = 13 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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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