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 27 May 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

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 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 ▶

P46662A

6/6/6/6/5/

P 4 6 6 6 2 A 0 1 2 0

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 Cold water fish require a minimum of 8 parts per million by mass (ppm) of oxygen dissolved in water.

The minimum mass of oxygen required in 1 kg of water is

☒ **A** 8×10^{-6} g

☒ **B** 8×10^{-3} g

☒ **C** 8×10^{-2} g

☒ **D** 8×10^{-1} g

(Total for Question 1 = 1 mark)

2 Calculate the total number of **atoms** in 8.5 g of CH_2Cl_2.

DATA: Molar mass of CH_2Cl_2 = 85 g mol^{-1}.

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

☒ **A** 1.8×10^{23}

☒ **B** 2.4×10^{23}

☒ **C** 3.0×10^{23}

☒ **D** 3.0×10^{24}

(Total for Question 2 = 1 mark)

3 50 cm^3 of hydrogen is mixed with 25 cm^3 of chlorine. The gases react as shown in the equation below.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

What is the total volume of gas present at the end of the reaction?

[All gas volumes are measured at the same temperature and pressure.]

☒ **A** 75 cm^3

☒ **B** 100 cm^3

☒ **C** 125 cm^3

☒ **D** 150 cm^3

(Total for Question 3 = 1 mark)

4 Sodium hydrogencarbonate decomposes on heating.

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

What is the maximum volume of carbon dioxide, in dm^3, which could be obtained by heating 0.25 mol sodium hydrogencarbonate?

The gas volume is measured at room temperature and pressure when the molar volume of a gas = 24 $dm^3\,mol^{-1}$.

☒ **A** 3

☒ **B** 6

☒ **C** 12

☒ **D** 24

(Total for Question 4 = 1 mark)

5 An experiment was carried out to measure the enthalpy change of the following reaction.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

50 cm^3 of hydrochloric acid was mixed with 50 cm^3 of sodium hydroxide solution. Each solution contained 0.10 mol solute. The temperature rise was 12 °C.

Energy transferred (J) = mass of solution × 4.2 × change in temperature

Assume the density of all solutions is 1.0 g cm^{-3}.

What is the enthalpy change of the reaction in kJ mol^{-1}?

☒ **A** $-\frac{50 \times 4.2 \times 12}{0.1 \times 1000}$

☒ **B** $-\frac{50 \times 4.2 \times 12}{0.2 \times 1000}$

☒ **C** $-\frac{100 \times 4.2 \times 12}{0.1 \times 1000}$

☒ **D** $-\frac{100 \times 4.2 \times 12}{0.05 \times 1000}$

(Total for Question 5 = 1 mark)

6 In the synthesis of ammonia, 56.0 g nitrogen was reacted with excess hydrogen.

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

The mass of ammonia produced was 6.00 g.

What is the percentage yield of ammonia?

☒ **A** 5.66

☒ **B** 8.82

☒ **C** 9.10

☒ **D** 10.7

(Total for Question 6 = 1 mark)

7 Which of the following has the smallest ionic radius?

☒ **A** O^{2-}

☒ **B** F^-

☒ **C** Na^+

☒ **D** Mg^{2+}

(Total for Question 7 = 1 mark)

8 Magnesium chloride crystals were prepared using the following reaction.

$$2HCl(aq) + MgO(s) \rightarrow MgCl_2(aq) + H_2O(l)$$

(a) The ionic equation for this reaction is

(1)

☒ **A** $2Cl^-(aq) + Mg^{2+}(s) \rightarrow MgCl_2(aq)$

☒ **B** $2Cl^-(aq) + MgO(s) \rightarrow MgCl_2(aq) + O^{2-}(l)$

☒ **C** $2H^+(aq) + 2Cl^-(aq) + MgO(s) \rightarrow Mg^{2+}(Cl^-)_2(aq) + H_2O(l)$

☒ **D** $2H^+(aq) + MgO(s) \rightarrow Mg^{2+}(aq) + H_2O(l)$

(b) The amount of hydrochloric acid used was 0.10 mol. Which of the following solutions of hydrochloric acid contains this amount of HCl?

(1)

☒ **A** 100 cm^3 of 0.10 mol dm^{-3}

☒ **B** 40 cm^3 of 0.25 mol dm^{-3}

☒ **C** 25 cm^3 of 0.40 mol dm^{-3}

☒ **D** 20 cm^3 of 5.00 mol dm^{-3}

(c) An **excess** of magnesium oxide was reacted with the 0.10 mol of hydrochloric acid.

Which of the following is the **smallest** mass which would provide an excess of magnesium oxide?

Molar mass of MgO = 40.3 g mol^{-1}

(1)

☒ **A** 1.50 g

☒ **B** 2.50 g

☒ **C** 3.00 g

☒ **D** 5.00 g

(d) What is the first step in obtaining pure hydrated crystals of magnesium chloride from the resulting reaction mixture?

(1)

☒ **A** Heating the mixture to concentrate it.

☒ **B** Allowing the mixture to evaporate slowly.

☒ **C** Filtering the mixture.

☒ **D** Distilling the mixture.

(e) Use the data below to calculate the number of moles of water of crystallization in each mole of hydrated magnesium chloride.

Substance	Molar mass / g mol^{-1}
Magnesium chloride	95.1
Hydrated magnesium chloride	203.1

(1)

☒ **A** 2

☒ **B** 4

☒ **C** 6

☒ **D** 8

(Total for Question 8 = 5 marks)

9 What is the equation for the lattice energy of magnesium chloride?

- ☒ **A** $Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$
- ☒ **B** $Mg^{2+}(s) + 2Cl^-(g) \rightarrow MgCl_2(s)$
- ☒ **C** $Mg^{2+}(g) + 2Cl^-(g) \rightarrow MgCl_2(s)$
- ☒ **D** $Mg^{2+}(g) + 2Cl^-(g) \rightarrow MgCl_2(g)$

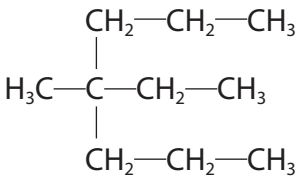
(Total for Question 9 = 1 mark)

10 A compound has the composition by mass of 54.5% C, 9.1% H and 36.4% O.
What is its empirical formula?

- ☒ **A** C_2H_2O
- ☒ **B** C_2H_4O
- ☒ **C** C_4H_9O
- ☒ **D** C_6HO_4

(Total for Question 10 = 1 mark)

11 What is the IUPAC name of the following hydrocarbon?



- ☒ **A** 2,2-dipropylbutane
- ☒ **B** 4-methyl-4-propylhexane
- ☒ **C** 2-ethyl-2-propylpentane
- ☒ **D** 4-ethyl-4-methylheptane

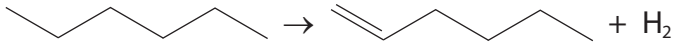
(Total for Question 11 = 1 mark)

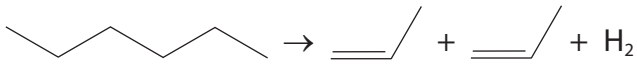
12 Which of the following shows geometric isomerism?

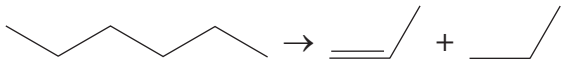
- ☒ **A** propene
- ☒ **B** but-1-ene
- ☒ **C** but-2-ene
- ☒ **D** 2,3-dimethylbut-2-ene

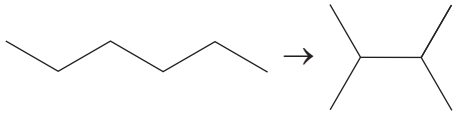
(Total for Question 12 = 1 mark)

13 Which of the following is a reforming reaction?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 13 = 1 mark)

14 In the reaction of methane with chlorine, ultraviolet light causes

☒ **A** homolytic fission of the Cl—Cl bond in chlorine molecules.

☒ **B** heterolytic fission of the Cl—Cl bond in chlorine molecules.

☒ **C** homolytic fission of the C—H bond in methane molecules.

☒ **D** heterolytic fission of the C—H bond in methane molecules.

(Total for Question 14 = 1 mark)

15 In the mechanism of the reaction of methane with chlorine to form chloromethane, which of the following is a propagation step?

☒ **A** $\bullet CH_3 + \bullet Cl \rightarrow CH_3Cl$

☒ **B** $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + \bullet Cl$

☒ **C** $CH_4 + \bullet Cl \rightarrow CH_3Cl + \bullet H$

☒ **D** $\bullet CH_3 + Cl_2 \rightarrow \bullet CH_2Cl + HCl$

(Total for Question 15 = 1 mark)

16 The empirical formula of poly(ethene) is

☒ **A** CH

☒ **B** CH_2

☒ **C** C_2H_4

☒ **D** C_nH_{2n}

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

17 A mass spectrometer can be used to measure relative isotopic masses.

(a) State the meaning of the term **isotopes**.

(1)

.....

.....

(b) (i) In a mass spectrometer, a sample of the vapour of an element is ionized. State how this ionization is carried out.

(1)

.....

.....

(ii) Complete the equation showing the simplest ionization of a vaporised element **M**.

(1)

M(g) $\rightarrow$

(iii) How are the ions accelerated in the mass spectrometer?

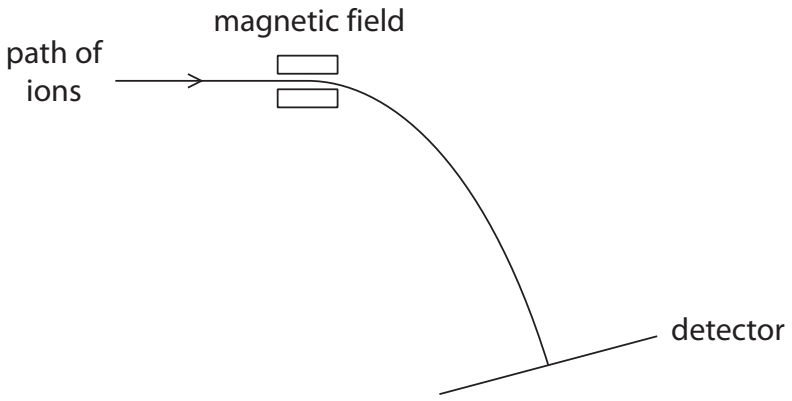
(1)

.....

.....

(iv) Ions with the same charge and travelling with the same velocity are then passed through a magnetic field.

(1)



The path of one ion is shown.
Add a line to the diagram to show the path of a **lighter** ion as it passes through the magnetic field and travels to the detector.

(c) A sample of silicon is analysed in a mass spectrometer.

Relative isotopic mass	Relative abundance
28	92·17
29	4·71
30	3·12

Calculate the relative atomic mass of silicon, showing your working.
Give your answer to **four** significant figures.

(2)

(d) A high resolution mass spectrometer measures masses to **four** decimal places.
The relative molecular mass of a compound is found to be 84.0581.

The relative atomic mass of an oxygen atom, ^{16}O, is 15.9949

The relative atomic mass of a hydrogen atom, ^{1}H, is 1.0079

Use these data to deduce whether the compound is C_6H_{12} or C_5H_8O. Show your working, and state the assumption you make.

(3)

Assumption

.....

.....

(e) A helium mass spectrometer is an instrument used to detect leaks in containers.

A sealed container filled with helium is placed in a vacuum chamber. Any helium leaking out of the container is detected by the mass spectrometer.

Suggest **one** reason that makes helium suitable for this purpose, other than its lack of reactivity.

(1)

.....

.....

.....

.....

(Total for Question 17 = 11 marks)

18 This question is about the elements aluminium and magnesium.

(a) Complete the electronic configuration for an **atom** of aluminium.

(1)

$1s^2$.....

(b) Complete the table to show the composition of an aluminium ion, Al^{3+}.

(1)

Subatomic particle	Number of particles in Al^{3+}
proton	
neutron	
electron	

(c) The table below shows the first four ionization energies of aluminium.

(i) Complete the table by identifying the orbital from which each electron is removed.

(2)

	First ionization energy	Second ionization energy	Third ionization energy	Fourth ionization energy
Ionization energy / kJ mol^{-1}	578	1817	2745	11 578
Orbital				

(ii) Write the equation, including state symbols, which represents the second ionization energy of aluminium.

(2)

*(iii) Explain why the second ionization energy of an element is always greater than the first ionization energy.

(2)

*(iv) Explain why the difference between the third and fourth ionization energies of aluminium is much larger than the difference between the first and second ionization energies.

(2)

(d) Aluminium is a silvery metal with a melting temperature of 933 K.

(i) Draw a labelled diagram of the bonding in aluminium.

(2)

(ii) The atomic number of magnesium is one less than aluminium. Would you expect magnesium to have a higher or lower melting temperature than aluminium? Justify your answer.

(2)

(iii) Draw the dot and cross diagram for magnesium chloride, $MgCl_2$.

Show the outer electrons only.

(2)

*(iv) Aluminium chloride has more covalent character than magnesium chloride.

Explain what this statement means. By considering the physical properties of these two chlorides, suggest **one** piece of evidence showing that aluminium chloride has more covalent character than magnesium chloride.

(3)

(Total for Question 18 = 19 marks)

19 Cordless hair-styler use 2-methylpropane as a fuel. The 2-methylpropane reacts with oxygen on the surface of a heated catalyst.

$$C_4H_{10}(g) + 6½O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

(a) Draw the **skeletal** formula of 2-methylpropane.

(1)

(b) When the hair-styler is switched on, the catalyst is heated using a battery. Suggest why the battery is not needed after the catalyst has been heated initially.

(2)

(c) The standard enthalpy changes of formation for the three compounds are:

Compound	Standard enthalpy of formation / kJ mol^{-1}
$C_4H_{10}(g)$	–134.5
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8

(i) The standard enthalpy change of formation of $H_2O(g)$ is –241.8 kJ mol^{-1}. Explain why this is less negative than the standard enthalpy change of formation of $H_2O(l)$.

(1)

(ii) Use the data in the table to calculate the standard enthalpy change of combustion of 2-methylpropane in kJ mol^{-1}.

Show your method, which may involve the use of a Hess cycle.

Include a sign and units in your answer.

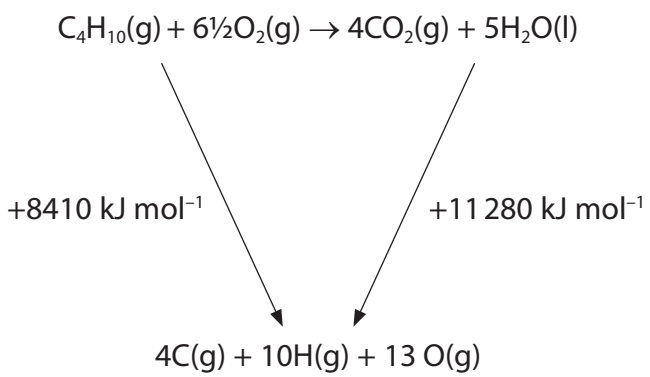
(3)

(iii) A refill canister for the cordless hair-styler holds 15 g of 2-methylpropane.

Calculate the energy in kJ which can be obtained from one canister.

(2)

(d) The enthalpy change of the reaction can also be calculated using the cycle below.



(i) Calculate the enthalpy change of the reaction using this cycle.

(1)

(ii) The enthalpy change of vaporization of water was one piece of data used to calculate the enthalpy changes shown beside the arrows in the cycle. What other information was needed?

(1)

.....

.....

(Total for Question 19 = 11 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

20 Propene is an alkene which can be produced by cracking some of the hydrocarbons in crude oil.

(a) Draw a dot and cross diagram showing the bonding in propene.
Show outer electrons only.

(2)

(b) (i) Propene is one product of the cracking of decane, $C_{10}H_{22}$.

Write the equation for the reaction in which one mole of decane is cracked to produce one mole of ethene, one mole of propene and one other product.
State symbols are not required.

(1)

(ii) A synthetic rubber can be made by polymerizing a mixture of ethene and propene.

Draw the structural formula of the repeat unit of this polymer which forms from one molecule of each alkene.

(2)

(c) Propene is also used to make propane-1,2-diol. Give the reagents and colour change when this product is made at room temperature.

(3)

Reagents .....

Colour change from ..... to .....

(d) The reaction of propene with bromine **water** is used as a test for the carbon-carbon double bond.

State the colour change in this test.

Draw the displayed formula of the organic product and give its name.

(3)

Colour change from ..... to .....

Displayed formula of product

Name .....

(e) Write the mechanism for the reaction of propene with **hydrogen bromide** to give the major product. Include relevant dipoles.

(4)

*(f) Molecules of the element bromine, Br_2, are not polar. Explain how **bromine** acts as an electrophile when it reacts with propene.

(2)

(g) In the United States of America, large deposits of shale gas have been discovered. This gas is trapped in rocks and can be extracted by "fracking" which involves breaking up the rock with water under pressure.

Shale gas typically contains about 90% methane, mixed with about 3% ethane, 0.6% propane, 0.2% butane and 0.2% pentane. The rest is hydrogen, nitrogen and carbon dioxide.

Suggest how the use of shale gas may affect the relative amounts of poly(ethene) and poly(propene) which are produced in the USA and justify your answer.

(2)

(Total for Question 20 = 19 marks)

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

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