Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: Core Principles of Chemistry

Tuesday 10 October 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates must have: Scientific 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.
- Try to answer every question.
- Check your answers if you have time at the end.
- Show all your working in calculations, include units where appropriate.

Turn over ▶

P50750A

6/6/6/5/5/1/

P 5 0 7 5 0 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 Crude oil is separated by fractional distillation in a fractionating column.

A compound obtained from higher up the column has a

(1)

☒ **A** higher boiling temperature and higher density.

☒ **B** higher boiling temperature and lower density.

☒ **C** lower boiling temperature and higher density.

☒ **D** lower boiling temperature and lower density.

(Total for Question 1 = 1 mark)

2 A hydrocarbon contains, by mass, 80% carbon and 20% hydrogen.

The **molecular** formula for the hydrocarbon is

(1)

☒ **A** CH_3

☒ **B** C_2H_5

☒ **C** C_2H_6

☒ **D** C_4H_{10}

(Total for Question 2 = 1 mark)

3 The number of alkene isomers with the molecular formula C_4H_8 is

(1)

☒ **A** 2

☒ **B** 3

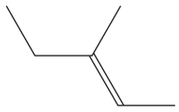
☒ **C** 4

☒ **D** 5

(Total for Question 3 = 1 mark)

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

4 What is the systematic name of the compound shown below?



(1)

☒ **A** *E*-3-methylpent-2-ene

☒ **B** *E*-3-methylpent-3-ene

☒ **C** *Z*-3-methylpent-2-ene

☒ **D** *Z*-3-methylpent-3-ene

(Total for Question 4 = 1 mark)

5 Propene gas is shaken with bromine water. The **main** product is

(1)

☒ **A** 1,2-dibromopropane

☒ **B** 1-bromopropan-2-ol

☒ **C** 2-bromopropan-1-ol

☒ **D** propane-1,2-diol

(Total for Question 5 = 1 mark)

6 The ionic equation for the reaction between copper(II) oxide and sulfuric acid is

(1)

☒ **A** $2H^+(aq) + SO_4^{2-}(aq) + CuO(s) \rightarrow H_2O(l) + CuSO_4(s)$

☒ **B** $2H^+(aq) + SO_4^{2-}(aq) + CuO(s) \rightarrow H_2O(l) + Cu^{2+}(aq) + SO_4^{2-}(aq)$

☒ **C** $2H^+(aq) + CuO(s) \rightarrow H_2O(l) + Cu^{2+}(aq)$

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

(Total for Question 6 = 1 mark)

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

7 How many neutrons are present in 1.0 g of helium?

[Avogadro constant = 6.0×10^{23} mol^{-1}; molar mass of helium = 4.0 g mol^{-1}]

(1)

- ☒ **A** 3.0×10^{23}
- ☒ **B** 1.5×10^{23}
- ☒ **C** 1.0×10^{23}
- ☒ **D** 0.5×10^{23}

(Total for Question 7 = 1 mark)

8 Sodium sulfate is formed when sulfuric acid reacts with sodium chloride under suitable conditions.

$$H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl$$

[Molar mass / g mol^{-1}: $H_2SO_4 = 98.1$ $NaCl = 58.5$ $Na_2SO_4 = 142.1$ $HCl = 36.5$]

The atom economy by mass for the formation of sodium sulfate is

(1)

- ☒ **A** 64%
- ☒ **B** 66%
- ☒ **C** 80%
- ☒ **D** 91%

(Total for Question 8 = 1 mark)

9 The nitrogen dioxide content of air on a particular day was 0.150 ppm **by mass**. The density of the air was 1.225 kg m^{-3}.

What was the mass of nitrogen dioxide in 1 m^3 of air on that day?

(1)

- ☒ **A** 1.83×10^{-7} kg
- ☒ **B** 1.83×10^{-10} kg
- ☒ **C** 1.84×10^{-7} kg
- ☒ **D** 1.84×10^{-10} kg

(Total for Question 9 = 1 mark)

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

10 100 cm^3 of ethane, C_2H_6, is completely burned in 400 cm^3 of oxygen.

$$C_2H_6(g) + 3½O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

What is the final volume of the gas mixture, in cm^3, if all volumes are measured under standard conditions of 298 K and 100 kPa?

(1)

☒ **A** 200

☒ **B** 250

☒ **C** 500

☒ **D** 550

(Total for Question 10 = 1 mark)

11 Sodium reacts with water to produce hydrogen.

$$Na(s) + H_2O(l) \rightarrow NaOH(aq) + ½H_2(g)$$

What volume of hydrogen, in **cm^3**, under standard conditions, is formed when 2.3 g of sodium reacts with excess water?

[Molar volume of a gas = 24 dm^3 mol^{-1}, molar mass of sodium = 23.0 g mol^{-1}]

(1)

☒ **A** 1.2

☒ **B** 2.4

☒ **C** 1200

☒ **D** 2400

(Total for Question 11 = 1 mark)

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

12 Which of these compounds contains the greatest percentage by mass of nitrogen?

	Formula	Molar mass / g mol^{-1}
☒ **A**	$(NH_2)_2CO$	60
☒ **B**	NH_4NO_3	80
☒ **C**	NH_4Cl	53.5
☒ **D**	NH_4F	37

(1)

(Total for Question 12 = 1 mark)

13 The melting temperatures, in kelvin, of nine successive elements in the Periodic Table are given.
The numbers of the elements are not their atomic numbers.

Element	1	2	3	4	5	6	7	8	9
T_m / K	3950	63	55	53	25	371	922	933	1683

Which element is a noble gas?

(1)

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 5

(Total for Question 13 = 1 mark)

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

14 To calculate the heat energy change, Q, for a reaction in aqueous solution, the equation used is

$$Q = mc\Delta T$$

It is usual to take the value of c, the specific heat capacity of the solution, as the specific heat capacity of water, 4.18 J g^{-1} °C^{-1}, and the value of m, the mass of solution, as the volume of solution.

Which statement about these values is true?

(1)

☒ **A** Both these are exact values for the solution.

☒ **B** The value for c is exact but the value of m is approximate.

☒ **C** The value for c is approximate but the value of m is exact.

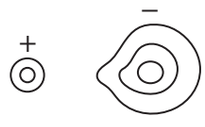
☒ **D** Both these are approximate values for the solution.

(Total for Question 14 = 1 mark)

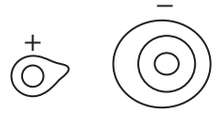
15 Which diagram best represents the shapes of the electron density contours for the ions in sodium fluoride?

(1)

☒ **A**

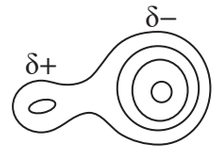


☒ **B**



☒ **C**

☒ **D**



(Total for Question 15 = 1 mark)

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

16 Ammonia gas is oxidised in the presence of a platinum catalyst.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

Substance	Standard enthalpy change of formation / kJ mol^{-1}
$NH_3(g)$	–46.1
NO(g)	+90.2
$H_2O(g)$	–241.8

From the data in the table, what is the standard enthalpy change of the reaction, in kJ mol^{-1}?

(1)

☒ **A** +905.6

☒ **B** +105.5

☒ **C** –105.5

☒ **D** –905.6

(Total for Question 16 = 1 mark)

17 In which reaction would the standard enthalpy change of reaction be closest to the value calculated only using mean bond energy data?

(1)

☒ **A** $CH_3CH_3(g) + Cl_2(g) \rightarrow CH_3CH_2Cl(g) + HCl(g)$

☒ **B** $CH_3CH_2CH_3(g) + Cl_2(g) \rightarrow CH_3CH_2CH_2Cl(l) + HCl(g)$

☒ **C** $CH_3CH_2CH_2CH_3(g) + Cl_2(g) \rightarrow CH_3CH_2CH_2CH_2Cl(l) + HCl(g)$

☒ **D** $CH_3CH_2CH_2CH_2CH_3(l) + Cl_2(g) \rightarrow CH_3CH_2CH_2CH_2CH_2Cl(l) + HCl(g)$

(Total for Question 17 = 1 mark)

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

18 When 0.10 mol of ammonium nitrate is dissolved in 100 cm^3 of water, the temperature falls by 5.0 K.

What would be the temperature fall when 0.02 mol of ammonium nitrate is dissolved in 10 cm^3 of water, under the same conditions?

(1)

☒ **A** 1.0 K

☒ **B** 2.0 K

☒ **C** 5.0 K

☒ **D** 10.0 K

(Total for Question 18 = 1 mark)

19 Which of the following enthalpy changes **cannot** be determined directly by experiment?

The enthalpy change of

(1)

☒ **A** combustion of carbon.

☒ **B** combustion of ethane.

☒ **C** formation of water.

☒ **D** formation of ethane.

(Total for Question 19 = 1 mark)

20 In which pair do **both** molecules contain a triple bond?

(1)

☒ **A** CO and N_2

☒ **B** CO and O_2

☒ **C** CO_2 and N_2

☒ **D** CO_2 and O_2

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

21 This question is about the preparation of ammonium iron(III) sulfate-12-water, $NH_4Fe(SO_4)_2.12H_2O$. It is a double salt containing ammonium ions, iron(III) ions, sulfate ions, and water of crystallisation.

(a) The first step of a preparation is to make iron(III) sulfate solution.
0.050 mol of iron(II) sulfate-7-water is dissolved in dilute sulfuric acid.
This solution is heated to boiling and concentrated nitric acid is added in portions of about 1 cm^3, until the reaction is complete.

$$6FeSO_4(aq) + 2HNO_3(aq) + 3H_2SO_4(aq) \rightarrow 3Fe_2(SO_4)_3(aq) + 2NO(g) + 4H_2O(l)$$

(i) Write the ionic equation for this reaction. State symbols are not required.

(2)

(ii) Calculate the mass of 1 mol of iron(II) sulfate-7-water, $FeSO_4.7H_2O$.

[A_r Fe = 55.8, S = 32.1, O = 16, H = 1]

(1)

(iii) Calculate the mass of 0.050 mol of iron(II) sulfate-7-water.

(1)

(iv) Show that 12.5 cm^3 of 2.0 mol dm^{-3} sulfuric acid is the minimum amount of sulfuric acid needed to react with 0.050 mol of iron(II) sulfate-7-water.

(2)

(v) Name the piece of apparatus which should be used to add portions of about 1 cm^3 of concentrated nitric acid while the mixture is boiling.

(1)

.....

(vi) After each addition of the nitric acid, a drop of the mixture is added to potassium hexacyanoferrate(III) solution. If iron(II) ions are present, the following reaction occurs.

$$2K_3[Fe(CN)_6](aq) + 3Fe^{2+}(aq) \rightarrow Fe_3[Fe(CN)_6]_2(s) + 6K^+(aq)$$

State the type of reaction that occurs between iron(II) ions and potassium hexacyanoferrate(III).

(1)

.....

(b) The second step of this preparation is to make ammonium sulfate solution by neutralising 12.5 cm^3 of dilute sulfuric acid.

(i) Write the equation, including state symbols, for the formation of ammonium sulfate by neutralising dilute sulfuric acid with ammonia solution.

(2)

(ii) Calculate the minimum volume of 2.0 mol dm^{-3} ammonia solution needed to react with 12.5 cm^3 of 2.0 mol dm^{-3} sulfuric acid.

(1)

(iii) In practice, it is difficult to ensure the concentration of ammonia solution is exactly 2.0 mol dm^{-3}, so a slight excess is usually needed. Describe a test and its result that could be used to show that excess ammonia solution has been added.

(2)

.....

.....

.....

.....

(c) The next step of the reaction is to mix the solutions of iron(III) sulfate and ammonium sulfate. To obtain crystals, the solution is concentrated by boiling off some of the water.

(i) How would you know if sufficient water has been removed?

(1)

.....

.....

(ii) State the best way to ensure that **large** crystals form from the concentrated solution.

(1)

.....

.....

(iii) When the crystals have formed, the mixture is filtered.

State the **two** practical steps then needed to obtain pure, dry crystals.

(2)

.....

.....

.....

.....

(d) The process gives a 40% yield of ammonium iron(III) sulfate-12-water. Calculate the mass of crystals formed from the initial 0.050 moles of iron(II) sulfate-7-water.

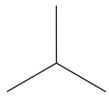
1 mol of iron(II) sulfate forms 1 mol of ammonium iron(III) sulfate.

[Molar mass ammonium iron(III) sulfate-12-water = 482 g mol^{-1}]

(2)

(Total for Question 21 = 19 marks)

22 2-methylpropane, previously known as isobutane, is a gas under standard conditions.



2-methylpropane

(a) (i) Give the empirical formula for 2-methylpropane.

(1)

(ii) Explain why it is **not** essential to give the prefix '2-' in the name 2-methylpropane.

(1)

.....

.....

(b) 2-methylpropane is used in fuels for portable camping stoves and as a refrigerant.

(i) Write the chemical equation for the complete combustion of 2-methylpropane. State symbols are not required.

(1)

(ii) Suggest the safety hazard associated with its use as a refrigerant.

(1)

.....

.....

(c) 2-methylpropane reacts with chlorine, in the presence of ultraviolet radiation, to form 2-chloro-2-methylpropane, molecular formula C_4H_9Cl, and other products.

(i) State the type and mechanism of this reaction.

(2)

(ii) Write an equation to show the initiation step of this reaction, using curly half-arrows.

(1)

(iii) Write the **two** equations to show the propagation steps for this reaction to form 2-chloro-2-methylpropane. Use molecular formulae.

Curly half-arrows are not required.

(2)

(d) One minor product of this reaction is 2,2,3,3-tetramethylbutane.

(i) Give the **structural** formula of 2,2,3,3-tetramethylbutane.

(1)

(ii) Name the type of step in the mechanism that produces 2,2,3,3-tetramethylbutane.

(1)

(iii) Explain how 2,2,3,3-tetramethylbutane forms as one of the products in this reaction.

(1)

.....

.....

.....

.....

(e) 2-methylpropane is used to make 2-methylpropene.

(i) What type of reaction occurs?

(1)

.....

*(ii) 2-methylpropene reacts with hydrogen bromide.

Give the mechanism for this reaction forming the **major** product.
Use appropriate curly arrows and show the relevant dipole and lone pair.

(4)

(iii) In the presence of a suitable catalyst, 2-methylpropene forms a mixture of dimers. Two of these dimers react with hydrogen to form 2,2,4-trimethylpentane.

Draw the **skeletal** formula for 2,2,4-trimethylpentane. Use this to draw the **skeletal** structure of one of the dimers formed from 2-methylpropene.

(2)

2,2,4-trimethylpentane

Dimer

(f) 2,2,4-trimethylpentane is also known as isooctane. It was first added to fuel for internal combustion engines in 1926. From this, the octane rating of fuel was devised by assigning a value of 100 to isooctane and a value of 0 to heptane.

(i) What is the structural feature of isooctane which gives it a higher octane rating than heptane?

(1)

.....

.....

(ii) Suggest **one** advantage of using a high octane fuel.

(1)

.....

.....

(Total for Question 22 = 21 marks)

23 This question is about the elements chlorine, argon and potassium.

Data for atomic numbers (Z), relative atomic masses (A_r), first ionisation energies (E_{m1}), and standard enthalpy changes of atomisation ($\Delta H^{\ominus}_{at}$) for these elements are given in the table.

Element	Z	A_r	E_{m1}/ kJ mol^{-1}	$\Delta H^{\ominus}_{at}$ / kJ mol^{-1}
Chlorine	17	35.5	1251	121.7
Argon	18	39.9	1521	0
Potassium	19	39.1	419	89.2

(a) (i) Give **two** reasons why the standard enthalpy change of atomisation of argon is zero.

(2)

*(ii) In the Periodic Table, elements are placed in order of increasing atomic number.

Use the data in the table to explain why elements are **not** placed in order of increasing atomic mass.

(2)

(b) Chlorine contains two isotopes ^{35}Cl and ^{37}Cl.

(i) State the numbers of subatomic particles in the nucleus of each isotope.
Use these to explain what is meant by the term isotope.

(2)

(ii) A sample of chlorine has a relative atomic mass of 35.453.

Calculate the percentage abundance of each of the isotopes of chlorine in this sample.

Give your answer to four significant figures.

(2)

(c) (i) Give the equation for the first ionisation energy of chlorine. Include state symbols.

(1)

*(ii) Explain why argon has a higher first ionisation energy than chlorine.

(2)

(iii) Draw the shape of the outermost occupied orbital in an argon atom and in a potassium atom. Label each orbital as s, p or d.

(2)

Argon Potassium

(d) Potassium burns in chlorine to form potassium chloride.

(i) Draw a dot and cross diagram for potassium chloride showing **all** electrons and charges.

(2)

(ii) State how potassium ions, chloride ions and argon atoms are similar.

(1)

.....

(e) (i) Name the law which is applied in a Born-Haber cycle.
State the law.

(1)

Name .....

Law .....

.....

(ii) The following data can be used in the Born-Haber cycle for potassium chloride.

Lattice energy of potassium chloride = −711 kJ mol^{-1}

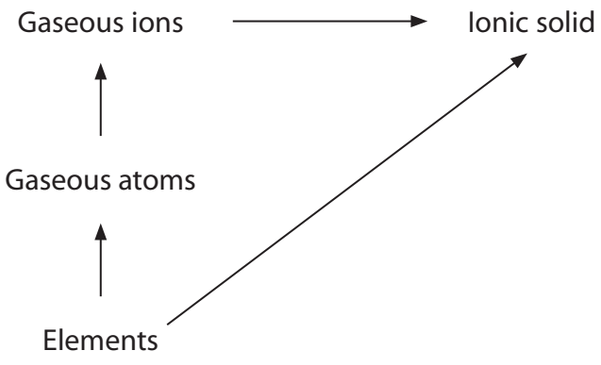
Standard enthalpy change of formation of potassium chloride = −436.7 kJ mol^{-1}

Standard enthalpy change of atomisation of potassium = +89.2 kJ mol^{-1}

Standard enthalpy change of atomisation of chlorine ($\frac{1}{2}Cl_2$) = +121.7 kJ mol^{-1}

First ionisation energy of potassium = +419 kJ mol^{-1}

The following diagram summarises the Born-Haber cycle for the formation of an ionic solid such as potassium chloride from its elements.



Label the arrows with the appropriate **values** and hence calculate the electron affinity of chlorine.

(3)

(Total for Question 23 = 20 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: 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

* Actinide 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
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